AD

EN-84-13

STRESS ANALYSIS
ON
SCREW THREAD

A. R. YAO and J. A. DORAN

AUGUST 1984

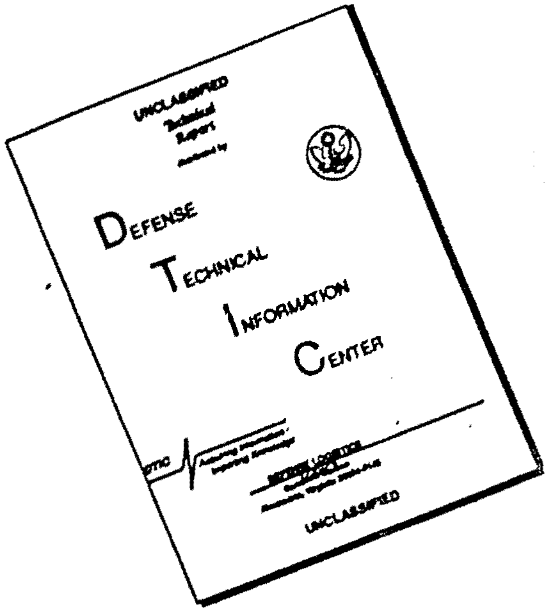
U.S. ARMY
AMCCOM

FINAL TECHNICAL REPORT

DISTRIBUTION STATEMENT
Approved for public release: distribution unlimited.

ENGINEERING DIRECTORATE
ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS 61299-5000

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

BLANK PAGES IN THIS DOCUMENT WERE NOT FILMED

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER EN-84-13	2. GOVT ACCESSION NO. AD A159347	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Stress Analysis on Screw Thread		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A. R. Yao and J. A. Doran		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rock Island Arsenal SMCRI-ENE Rock Island, IL 61299		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Rock Island Arsenal SMCRI-ENE Rock Island, IL 61299		12. REPORT DATE August 1984
		13. NUMBER OF PAGES 180
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

1. Screw Thread
2. Thread Form
3. Deviation
4. Load Capacity
5. Safety Factor
6. Fatigue

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents a thread joint analysis method which has been applied to an interactive computer program for evaluation of thread form deviations encountered in production. Thread forms covered include FED-STD-H28 standards and special forms generated by user supplied input. The analysis method, which includes static and dynamic analysis using elastic theory, provids thread joint performance indicators in the form of static load capacity and fatigue safety factor for various life cycle ranges. The analysis method and subsequent program is a... useful for developing thread joint design criteria and

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20. Abstract

verification of existing designs.

A-1

FOREWORD

This report was prepared by A. R. Yao and J. A. Doran, Rock Island Arsenal, Engineering Directorate, Rock Island, Illinois. The purpose of this screw thread stress analysis program was to provide a tool for estimating load capacities and fatigue life cycles of threaded connection.

The program material contained herein is supplied without warranty or representation of any kind. Rock Island Arsenal assumes no responsibility and shall have no liability, consenquential or otherwise, of any kind arising from the use of this program material or any part thereof.

STRESS ANALYSIS ON SCREW THREAD

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

During the past several years of production at Rock Island Arsenal, approximately 10% of all submitted material nonconformances have directly involved thread forms. Variations in minor, pitch, and major diameters along with other geometry considerations in V, Acme, Buttress, and special thread forms; may adversely affect the assembly, life, and strength of a given thread joint. Nonconforming parts have ranged from common fasteners under static loading to recoil yokes and piston adapters subjected to enormous weapon firing loads. The cost/scheduling impact and critical function requirements have established a crucial need for a rapid and reliable thread joint evaluation method.

Thread analysis procedures to date include (1) Precedent Method, (2) Thread Class Substitution, (3) Routine Stress Analysis, and (4) Testing.

The Precedent Method, as the name implies, bases a thread nonconformance evaluation on previous evaluations of similar types under similar loading and environmental conditions, where these results may be derived from calculations, experiments, or experience. This method is practical and effective, being employed whenever a reasonable and verifiable precedent case can be found. The quantitative "how much" or "how bad" answers, however, must be obtained by other means.

The Class Substitution Method, somewhat similar in philosophy to

the Precedent Method, uses the tolerance variations within thread class specifications as a criterion for acceptance. The method is primarily a "rule-of-thumb" approach and also lacks quantitative accessment of thread joint performance. The Class Substitution Method, used only occasionally for critical fit applications, does have the distinct advantage of providing distinct documented limits, but is generally so conservative as to disqualify thread conditions that still possess adaquate strength.

Routine Stress Analysis, using the more readily available textbook references, serve to provide quantitative analysis of limited accuracy, being based on several simplifying and gross assumptions. Highly detailed stress results, leading to more accurate analysis, is not a simple exercise and must generally be conducted by persons having that specialized discipline. Usually, evaluation response time for a given occurance precludes this type of in-depth analysis.

The testing approach, used sparingly due to cost and time constraints, offers perhaps the most accurate and verifiable means of analyzing thread nonconformances. Testing as a sole means of evaluation, however, would require experimental recreation of exact geometry and loading conditions per given nonconformance. More general experiments designed to evaluate "trends" due to certain geometry and load conditions can provide useful and interesting results, but seldom provide the required degree of accuracy.

An alternative evaluative method, which is being documented in this report, involves development of three-dimensional state-of-stress equations using specific thread geometry relationships and Heywood's formula. Thorough literature research on thread analysis, both domestic and foreign, have confirmed and further refined this analytical approach to solve joint strength of nonconforming threads. However, as with any analytical solution, several key assumptions were required to simplify complicated geometries and loading conditions. Some experimental data adopted from literatures and mathematical model were integrated into an interactive computer program for solution of user supplied thread geometry, applied loads and material property parameters. In this report, both static analysis and fatigue analysis were provided under assumption of elasticity.

2. Thread Geometry

A screw thread is a complex configuration comprised of several elements and characteristics. According to definition of FED-STD-H28 (1) and ANSI B1 (2) handbooks, a screw thread is a ridge, usually of uniform section and produced by forming a grove in the form of a cylinder. (Taper thread is not included in this report.) A thread is a portion of a screw thread encompassed by one pitch. On a single-start thread it is equal to one turn.

There are several basic thread forms such as V thread, Acme thread, Buttress thread, square thread and special thread such as Watervliet 20/45 modified Buttress thread. Due to loading conditions and applications, threads are identified with thread type, thread series, size, fit or class, and some special specifications. Figure 2.1 shows a typical thread geometry. For detail definition, geometry, allowance, tolerance and limit of size of thread forms, FED-STD-H28 and ANSI B1 handbooks are recommended. Typical thread forms, thread series and classes are listed as follow:

UNC: Unified coarse thread, Classes-1A,2A,3A,1B,2B and 3B.

UNF: Unified fine thread, Classes-1A,2A,3A,1B,2B and 3B.

UNEF: Unified extra fine thread, Classes-1A,2A,3A,1B,2B and 3B.

UNM: Unified miniature thread

UNJ: Unified controlled root radius thread, ANSI B1.15.

UNR: Unified controlled root radius thread, ANSI B1.14.

4UN,6UN,8UN,12UN,16UN,20UN,28UN and 32UN: Unified thread,

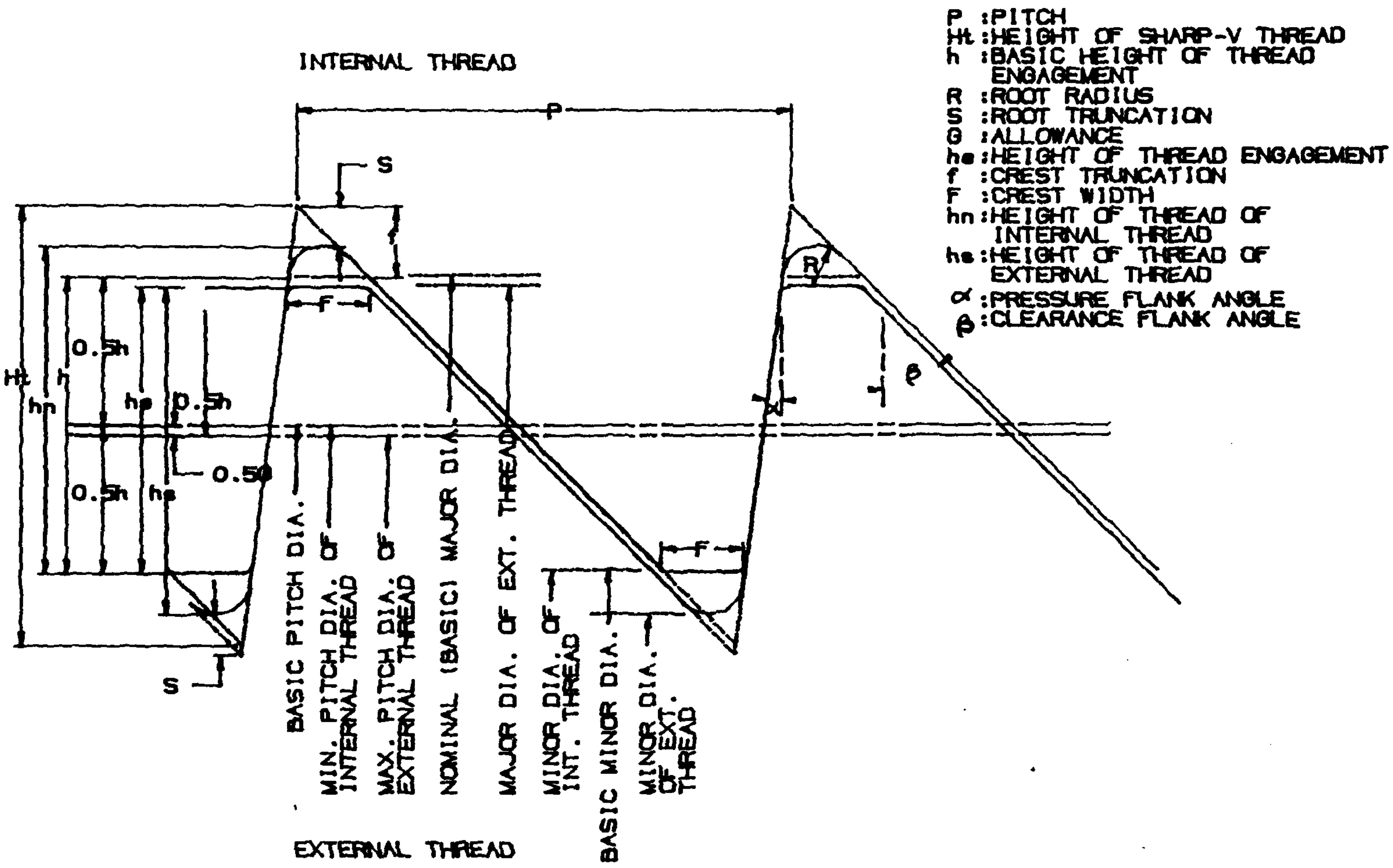


FIGURE 2.1 TYPICAL THREAD GEOMETRY.

Classes-1A,2A,3A,1B,2B and 3B.

ACME: Acme thread, two general applications for Acme thread used chiefly for purpose of producing traversing motions on machines and tools. Acme thread is divided into three general classes, 2G,3G and 4G, and five centralizing classes, 2C,3C,4C,5C and 6C.

STUB ACME: Used for unusual applications pertinent to Acme thread but where a coarse pitch or shallow depth is required. While no class callout, the Stub Acme corresponds to class 2G of the Acme thread.

BUTT and PUSH-BUTT: Buttress thread for pull or push type, used where high stresses are along the thread axis in one direction only.

Classes-1A,2A,3A,1B,2B and 3B.

Thread design is to a large extent empirical and is partially based on previous experience with similar designs and the judgment of the designer. The interrelation of length of engagement, minimum major diameter of the external thread, maximum minor diameter of the internal thread, and the strength of the assembled thread needs to be understood and carefully considered in order to produce the optimum design of a special thread. It is not economical to use either a length of thread engagement which is longer than required or shorter than that which will develop the full strength of the externally threaded member. Other factors such as loading conditions and geometry restrictions required careful analysis and adjustment of the design with respect to selection of the diameter-pitch combination, the class of thread, length of engagement, and minor and major diameter tolerances.

3. Theoretical Background

3.1 Failure Modes

The screw thread is one of the machine elements, in the form of a nut and bolt or stud, which have widespread application for virtually every machine and structure. A screw thread differs from a conventional cylindrical notched specimen in that, firstly, a screw thread consists of a series of adjacent notches and, secondly, the load is transmitted through the stress concentration, that is, the nut transmits the load to the bolt through the flank and root radius of the thread. The threaded connections are, in general, subjected to tension, compression, shear, bending and torsion, statically and dynamically. Torsional stress is presented in the threaded connection during tightening, however, the threaded connection will unwind slightly during the initial period of operation under dynamic loading, and relieve the torsional stress. In addition to the stress due to axial loading (tension and compression), the thread contact surface transmits bending stress at the thread roots.

Thread failure modes are mainly: (1) shear failure, and (2) failure due to maximum fillet stress at thread roots subjected to uniaxial static or fatigue loadings. Other detrimental factors for threaded connections are fretting on thread contact surface and eccentric loading conditions.

Under simple tension test of a threaded connection with thread form manufactured per designed specification, the failure is due to bending (or maximum fillet stress). However, according to Smith (3), the

truncated or deviated threads fail in bending and shear where the degree of failure due to shear increasing with the amount of truncation. The effect of deviation or truncation on thread failure strength is not too great. Tests on both ground and rolled threads showed that a reduction in the depth of engagement, even to 25% of normal, caused no significant loss in fatigue strength, provided that the truncation was either divided equally between the external and internal thread or nearly all in the internal thread.

Thread surface finish, degree of lubrication, accuracy of thread form machining and material of thread members are factors which relate to fretting and galling. When a threaded connection is subjected to cyclic loading, fretting may occur along the thread contact surface. As the fretting area is remote from the region of maximum fillet stress, according to Field (4), fretting plays no part in crack initiation, fatigue cracks grew from the thread roots not from an area of fretting. Eccentric loading condition on threaded connection may be produced by inclination of the contact face of the nut and the adjacent structural member or by deformation of the structure under the working loads. The eccentric loads will introduce additional bending stress to the thread pressure flank and increase the maximum fillet stress in the thread root area, and therefore increase the chance of failure at the thread root area. In this report, fretting, galling, and eccentric loading conditions will not be considered.

3.2 Load Distribution Along Threaded Connection

The distribution of thread loads along a threaded connection has been studied theoretically by Sopwith (5). A thread load concentration factor H was introduced to account for nonuniform thread load distribution along the thread helix. This factor is defined as the ratio of the maximum thread load per inch of thread helix to the average thread load per inch over the entire length of engagement of external and internal threads.

The experimental study on this topic was carried out by Goodier (6), Hetenyi (7) and Chalupni (8), etc.. The highest thread load was found at the external thread at about one turn in from the loaded face of the internal thread. This occurred because the load carried by a external thread was not distributed uniformly between the mating threads, the first engaged thread carrying a higher percentage of the total thread load than succeeding threads. The thread load concentration factor were estimated varying from 1 to 4. This factor depends on coefficient of friction between internal and external threads and thread geometries, such as thread form, equivalent outside diameter and height of internal thread member, hollow diameter in external thread member, pitch and included angle. From a photoelastic model of threaded connection having six engaged threads, Cazaud (9) found that the percentages of the external thread load carried by the first and subsequent engaged threads were 34, 23, 16, 11, 9 and 7, respectively. The thread load concentration factor for this threaded connection is 2.04. Both theoretical

and experimental studies were performed under elastic condition. If the external loads applied to the thread joint causes the thread root regions to deform plastically, the resulting thread load distribution along the contact surface will become more uniform. This indicates that strength of a thread connection can be improve by prestressing the thread connection such that the material at thread roots region must to be equal to or become close to yield point.

Threaded connections of the cannon breech mechanism, consisting of breech ring, breech block and gun tube, were studied by using both two and three dimensional photoelasticity methods by Marino and Riley (10). Their attempt was to optimize thread root contours for designing cannon breech mechanism. In the breech mechanism the breech block and gun tube have external threads, whereas the breech ring threads are internal. The threads on all components are sectored to permit quick and convenient assembly of the parts.

Experimental data from 3-dimensional photoelastic test for breech block with standard Buttress thread, the mean maximum fillet stress at the center of the sector is 6.16 times p (internal pressure applied in the breech mechanism). The mean maximum fillet stress at the edge of thread sector of the breech block is 7.45 times p, and H is 1.114. For breech ring with Buttress thread, the mean maximum fillet stress at the center of thread sector is 4.36 times p, and H is 1.69. Whereas, the mean maximum fillet stress at the edge of thread sector is 4.52 times p, and H is 1.66. In the similar test, 3/8" pitch V threads were tried in the breech mechanism.

For breech ring the mean maximum fillet stress at the center of thread sector is 3.3 times p, and H is 1.9, while the mean maximum fillet stress at the edge of thread sector is 3.6 times p and H is 1.7. In the same report, the same thread forms were tried and load distribution along the threaded connection were compared. The thread load concentration factor for Buttress thread H is averaging 1.5 for 3-D model, while for 2-D model the thread load concentration factor H is 2.48. Obviously, the thread load concentration factor in 3-D model is smaller than that in 2-D model.

Dynamic tests on full scale cannon breech mechanism were performed by Weigle and Lasselle (11). In the test a peak pressure of 48,000 psi and a rise time of 3.45 msec with operation at a rate of 68-70 cpm were applied. Thread forms of Buttress thread, V thread and modified 20/45 Buttress thread were used in the full scale dynamic tests. The thread load concentration factor H was estimated to be 1.4. In the interactive computer thread stress analysis program, the default value of thread load concentration factor H is 1.5. However, users have options to define H value ranged from 1 to 4.

3.3 Axial Load

The threaded connections are usually subjected to uniaxial loading. The axial loading conditions applied to external thread (bolt) and internal thread (nut) can be tension, and/or compression. The most frequent case of threaded connection, however, is external thread under tension and internal thread under compression. In this case, on the external thread, the axial tensile stress tends to increase the tensile fillet stress caused by thread load, while on the internal thread, the axial compressive stress tends to drease the tensile fillet stress caused by thread load, which increases the load capacity of internal thread. This is why, on most occasions external occasion, external threads (bolts) fail instead of the internal threads (nuts). In the case of cannon breech mechanism, both external thread (breech block and gun tube) and internal thread (breech ring) are subjected to tensile stresses.

For axial loading, according to Neuber (12) and Heywood (13), the maximum elastic stress concentration factor occurring in the vicinity of a row of grooves is not so great as that created by a single groove of the same geometry. The difference depending on the specimen and groove geometries and the distance between adjacent grooves. With multiple grooves, Neuber considered that the reduced stress concentration factor may attributed to a small effective depth of groove. In addition, the stress concentration factor for thread forms depend on included

angle ($\alpha+\beta$), equivalent outside diameter (Do), minimum major diameter (Dimin) of the internal thread, inside (hollow) diameter (d), and minimum minor diameter (Kemin) of the external thread. The stress concentration factor for a row of thread forms at the boundary of the thread root, in general, can be expressed as

$$Ka(\theta)=1+f(\alpha+\beta,\ rh/R,(Kemin-d)/(2rh)\ \text{or}\ (Do-Dimin)/(2rh),Cos2\theta) \qquad (3.3.1)$$

where $r=0.3(P/h)^{0.7}$, r is a factor less than unit, h is the thread height, R is the thread root radius and θ is an angle in degree measured from the bottom of the thread root. It is observed that for standard thread (Kemin-d)/(2rh) and (Do-Dimin)/(2rh) are always greater than 1.0. From Neuber's nomographs (12), the stress concentration factor ($Kae(\theta)$) of external thread due to axial load can be calculated by the equation

$$Kae(\theta)=1+\frac{1.25(K1-1)((Kemin/2R)^{\frac{1}{2}}-1)(1-((\alpha+\beta)/180)^{1+2.4(R/rh)^{\frac{1}{2}}})Cos2\theta}{((K1-1)^{2}+1.5625((Kemin/2R)^{\frac{1}{2}}-1)^{2})^{\frac{1}{2}}} \qquad (3.3.2)$$

$$\text{where } K1=\frac{0.6(rh/R)^{\frac{1}{2}}(6((Kemin-d)/2R)^{\frac{1}{2}}-1)}{(4rh/R+0.09(6((Kemin-d)/2R)^{\frac{1}{2}}-1)^{2})^{\frac{1}{2}}} \qquad (3.3.3).$$

Similarly, the stress concentration factor ($Kai(\theta)$) of internal thread due to axial load can be calculated by the equation

$$Kai(\theta)=1+\frac{(K2-1)(1.667(Dimin/2R)^{\frac{1}{2}}-0.5)(1-((\alpha+\beta)/180)^{1+2.4(R/rh)^{\frac{1}{2}}})Cos2\theta}{((K2-1)^{2}+(1.667(Dimin/2R)^{\frac{1}{2}}-0.5)^{2})^{\frac{1}{2}}} \qquad (3.3.4)$$

$$\text{where } K2=\frac{0.6(rh/R)^{\frac{1}{2}}(6((Do-Dimin)/2R)^{\frac{1}{2}}-1)}{(4rh/R+0.09(6((Do-Dimin)/2R)^{\frac{1}{2}}-1)^{2})^{\frac{1}{2}}} \qquad (3.3.5).$$

The fillet stress at the thread root area due to axial load (W) will be the product of the stress concentration factors (Kae or Kai) and nominal axial stress. The stresses of external and internal threads at fillet contours due to axial (tensile or compressive) loading can be calculated, respectively, by

$$St(\theta)=Kae(\theta)\ W\ (4/\pi)/(Kemin^2-d^2) \qquad (3.3.6)$$

and

$$St(\theta)=Kai(\theta)\ W\ (4/\pi)/(Do^2-Dimin^2) \qquad (3.3.7).$$

The maximum stresses take place at bottom of the thread root (θ=0), such that Kae(0)=Kae and Kai(0)=Kai.

3.4. Shear Failure

Thread shear failure is caused by excessive loading on the thread contact surface. Shear stress and effective shear area are dependent upon the relative tensile strength of the material of the external and internal threads. The formula for shear stress is

$$Ss= W/As \qquad (3.4.1)$$

where W =Total axial load, and As=Shear area. Total length of thread engagement helix at a projection diameter x can be expressed as

$$L(x)=n\cdot Le\cdot((\pi x)^{2}+P^{2})^{\frac{1}{2}} \qquad (3.4.2)$$

where Le=Length of thread connection axial engagegement

n=Number of threads per inch

P=1/n, Pitch.

When the external and internal threads are manufactured from materials of equal unit tensile strength and shear failure occurs, the failure will usually take place simultaneously in both threads at or close to the basic pitch diameter. The shear area will be

$$As=L(E)/(2n) \qquad (3.4.3)\ .$$

When the tensile strength of the external thread material greatly exceeds that of the internal thread material, shear failure will usually take place in the internal thread at or close to minimum major diameter of the external thread. The shear area will be

$$As=0.5\ L(Demin)\ (P+(Tan\ \ +Tan\ \ )(Demin-Eimax)) \qquad (3.4.4)$$

where Demin=Minimum major diameter of external thread

Eimax=Maximum pitch diameter of internal thread.

When tensile strength of the internal thread material greatly exceeds that of external thread material, shear failure will usually take place in the external thread at or close to maximum minor diameter of internal thread. The shear area will be

$$As=0.5\ L(Kimax)\ (P+(Tan\ +Tan\ )(Eemin-Kimax)) \qquad (3.4.5)$$

where Kimax=Maximum minor diameter of internal thread

Eemin=Minimum pitch diameter of external thread.

3.5 Preload

Tightening and preload are recommended on some threaded connections due to mechanical or structural design criteria, such as functional and strength requirements. Statically, preloads improve locking effect of the thread joint. For example, sufficient tensile preload is required in pipe flange bolts to overcome the longitudinal forces caused by the pressure in the piping, so that the flanged connection does not leak. A similiar problem is faced in tightening the nut on the cylinder head of an engine block, so that the studs are all stressed equally and to a tension that precludes leakage. If the threaded connection subjected to cyclic loading, preload reduces the ratio of alternating stress (Sa) to mean stress (Sm) and that improves the fatigue resistance of the threaded connection, according to the fatigue fracture critertia in Sa-Sm diagram.

Preload is recommended only for the material of threaded connections with a stress-strain curve in which there is no clearly defined yield point and progresses smoothly upward until fracture. For the described material, proof load is defined as the maximum load applied to the material without creating permanent deformation. For static loading conditions, the torsional stress due to preload disappears after tightening, if the strain of the material pass plastic yielding. Therefore, the minimum preload is recommended as 90% of the proof load,

and takes the form

$$Fp=0.9SyAt \qquad (3.5.1)$$

where Sy is the yield stress and At is the stress area of the threaded connection. According to Federal Standard H-28 handbook, for steel parts with tensile strength up to 180 ksi, the stress area is computed from the following formula:

$$At=(\pi/4)(E-3h/4)^2 \qquad (3.5.2)$$

where E is basic pitch diameter and h is the thread height. A threaded connection subjected to slight movements will cause flattening of high spots, paint or dirt and will relieve the torsional friction. Thus, if the threaded connection does not fail during tightening, there is a very good chance that it will never fail under static loading condition. For cyclic loading condition, care must be taking for deciding direction of preload. According to Juvinall (14), an overload causing yielding produces residual stresses which are favorable to future overloads in the same direction and unfavorable to future overloads in the opposite direction. Apply preload only in the direction of anticipated service loads.

Torque required to provide the specified preload for thread joint

is

$$T=KpFpD \qquad (3.5.3)$$

where Kp is torque coefficient, and D is major diameter of the threaded connection. According to Shigley (15), Blake and Kurtz (16), no matter what size and condition of lubrication of the threaded connection, the torque coefficient Kp can be estimated as a constant 0.2, and equation (3.5.3) becomes

$$T=0.2FpD \qquad (3.5.4)\ .$$

The torque applied to the nut is used up in three ways. About 50% of it is used to overcome the friction between the bearing face of the nut and the member. About 40% of the applied torque is used to overcome thread friction, and the balance produces the bolt tension. Only the last two items contribute the torsion in the screw thread. During tightening the torsional stresses of external and internal threads due to torque become, respectively,

$$Tpe=(0.16/\pi)FpDemaxKemin/(Kemin^4-d^4) \qquad (3.5.5)$$

and

$$Tpi=(0.16/\pi)FpDoDimin/(Do^4-Dimin^4) \qquad (3.5.6)$$

where Demax=Maximum major diameter of external thread

Kemin=Minimum minor diameter of external thread

Dimin=Minimum minor diameter of internal thread

Do=Equvalent outside diameter of internal thread

d=Inside (Hollow) diameter of external thread.

3.6 Thread Load and Heywood's Formula

The screw thread on each thread form can be considered as a short, very wide cantilever, the width being the total length of the thread along the helix. If the thread load is applied at a relatively great distance from the thread root, the fillet stress at the thread root is caused by bending moment. However, if the thread load is applied close to the thread root, the nominal fillet stress can not be determined by merely considering the effect of bending moment. The well-known Lewis formula (17) calculating the maximum fillet stress for loaded projection, such as screw and gear tooth, is based on a pure bending effect. The modified Lewis formula proposed combined bending and compression effects to assess the maximum fillet stress. But with introduction of stress concentration factor both Lewis formula and modified Lewis formula can only correctly correlate well with experimental results for a comparatively narrow range of shapes of loaded projection.

From photoelastic data, Heywood (18), Kelly and Pedersen (19) introduced load proximity and shear effects and proposed an empirical formula for estimating fillet stress for various type of loaded projections. Heywood's empirical formula correlates rather well, over a wide range of shapes of loaded projection, with the experimental results from different researchers. Heywood observed that, in case of screw thread, the maximum fillet stress occurred at approximately 30° to the flank. The Heywood's empirical formula take the form:

$$S_b = K_b(W/t\cos\alpha)\left(\frac{1.5a}{e^2} + \frac{0.45}{(be)^{\frac{1}{2}}} + \frac{\sin\phi}{2e}\right) \qquad (3.6.1)$$

where S_b=Maximun fillet stress due to a thread load $W/\cos\alpha$ applied to the thread projection

$K_b=(1+0.26(e/R)^{0.7})$ Fillet stress concentration factor

W =Axial load applied to the threaded connection

=Pressure flank

e =Dimension of resisting material

b =Straight line distance between point of the maximum tensile fillet stress and point of applied load

R =Thread root radius at point of maximum stress

a =Arm of bending moment

t =Projection thickness

ϕ=Angle defining direction of load with respect to the tangent to the fillet.

The first term in parentheses is Lewis bending moment term, the second is a load proximity term, increasing the stress as the point of loading

approaches the fillet, and the third is a shear effect term. The proximity term arises partly from the local distortion and complex load distribution occurring in the region where the load is applied, and partly from the effect of high rigidity near the base of the projection. A typical thread form with parameters in Heywood's empirical formula are defined in Figure 3.6.1. The maximum tensile fillet stress is estimated taking place at point A, and the maximum compressive fillet stress is estimated taking place at point B. The arm of the bending moment a is determined by the perpendicular distance from the mid-point C of AB on to the line of action of the load. The weakest semi-section of the projection is defined by the line AD of length e, this being the perpendicular from point A on the center line of the projection. The angle ϕ is related to wedge effect or friction force of the pressure flank of the threaded connection. By using finite element analysis, shear transfer rate was introduced and explored by O'Hara (20) by changing angle of applied load to the pressure flank.

If the thread loads are normal to pressure flank, then angle ϕ is 30 degrees. If height of sharp v-thread of thread form is Ht, root truncation is s as defined in FED-STD-H28 handbook, the parameters shown in Heywood's formula can be calculated as follow:

$$e = \frac{Ht - s - R(1 - \cos(60 - \alpha))}{\cos\alpha} \sin\left(\frac{\alpha + \beta}{2}\right) \qquad (3.6.2)$$

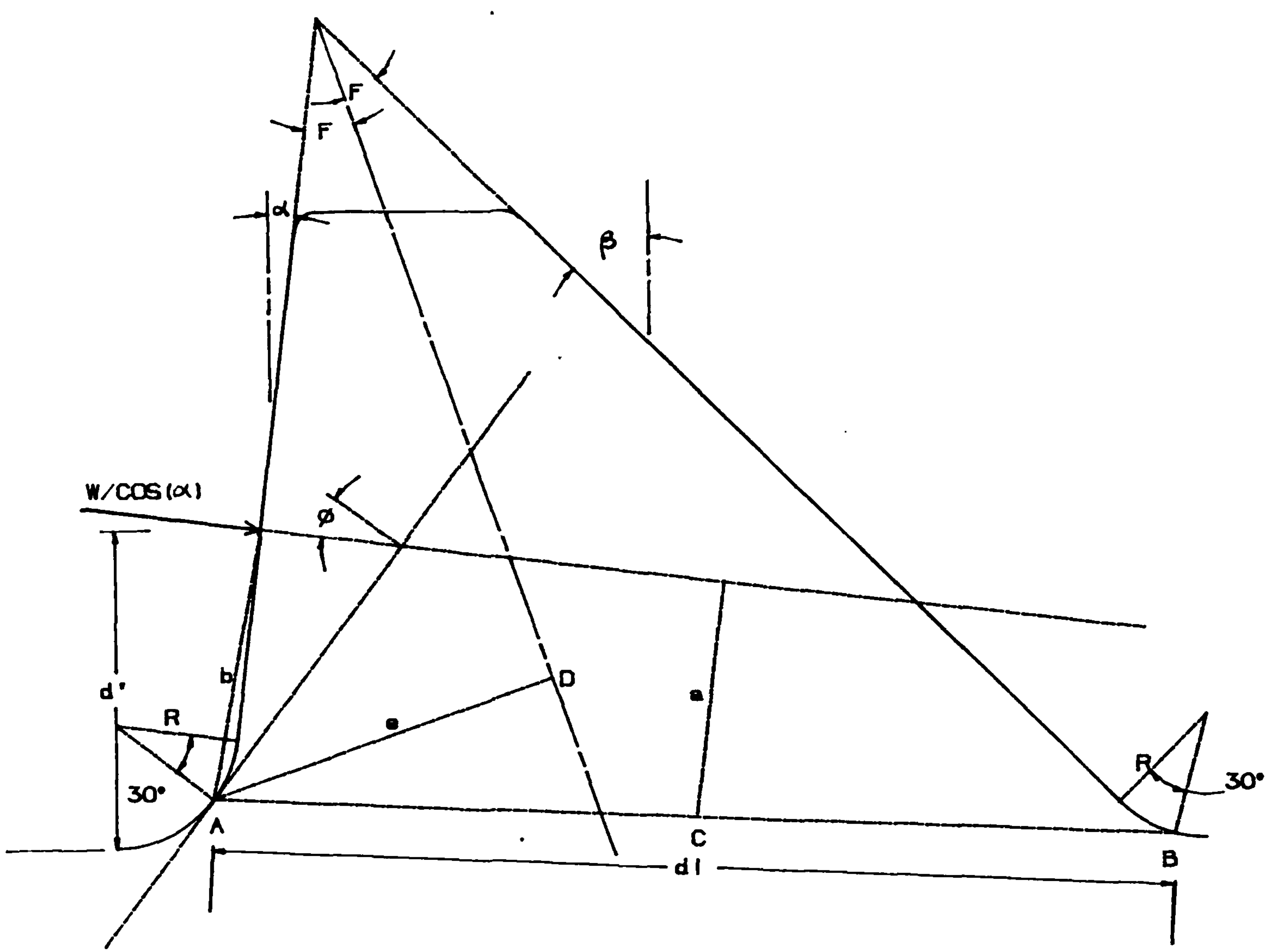


FIGURE 3.6.1 TYPICAL THREAD FORM WITH HEYWOOD'S PARAMETERS.

$$a = \frac{d' - R(1-\cos(60-\alpha))}{\cos\alpha} - \sin(\alpha+\theta)\,(d1/2 - R\tan(45-\alpha/2) + R\sin(60-\alpha)) \quad (3.6.3)$$

$$b = \frac{d' - R(1-\cos(60-\alpha))}{\cos\left(\tan^{-1}\left(\dfrac{d'\tan\alpha + R\tan(45-\alpha/2) - R\sin(60-\alpha)}{d' - R(1-\cos(60-\alpha))}\right)\right)} \quad (3.6.4)$$

where

$$d1 = m1/\cos(\theta) \quad (3.6.5)$$

$$\theta = \tan^{-1}(R\cdot(\cos(60-\beta)-\cos(60-\alpha))/m1) \quad (3.6.6)$$

$$m1 = R(\tan(45-\alpha/2)+\tan(45-\beta/2)-\sin(60-\alpha)-\sin(60-\beta))$$

$$+P/2+(\tan\alpha+\tan\beta)(Eemin-Kemin)/2 \quad \text{(for external thread)} \quad (3.6.7)$$

or

$$m1 = R(\tan(45-\alpha/2)+\tan(45-\beta/2)-\sin(60-\alpha)-\sin(60-\beta))$$

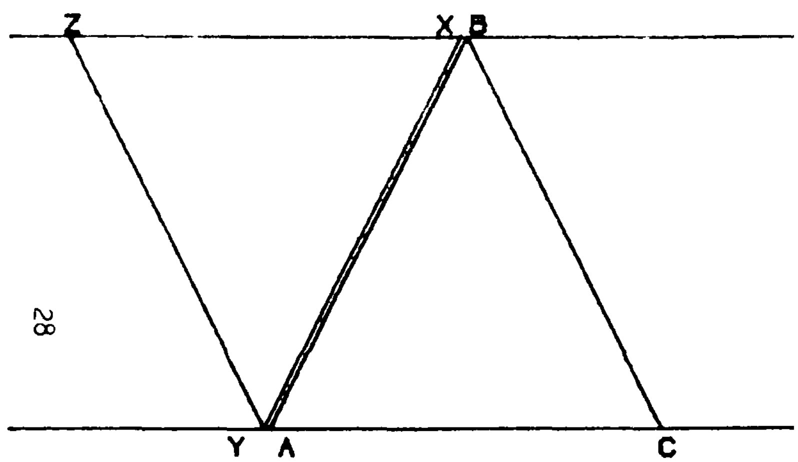
$$+P/2+(\tan\alpha+\tan\beta)(Dimin-Eimin)/2 \quad \text{(for internal thread)} \quad (3.6.8)$$

and d' is the distance from point of applied load to minimum minor diameter of the external thread (Kemin) or minimum major diameter of the internal thread (Dimin). The parameter d1 is the distance in between point A and point B as shown in Figure 3.6.1.

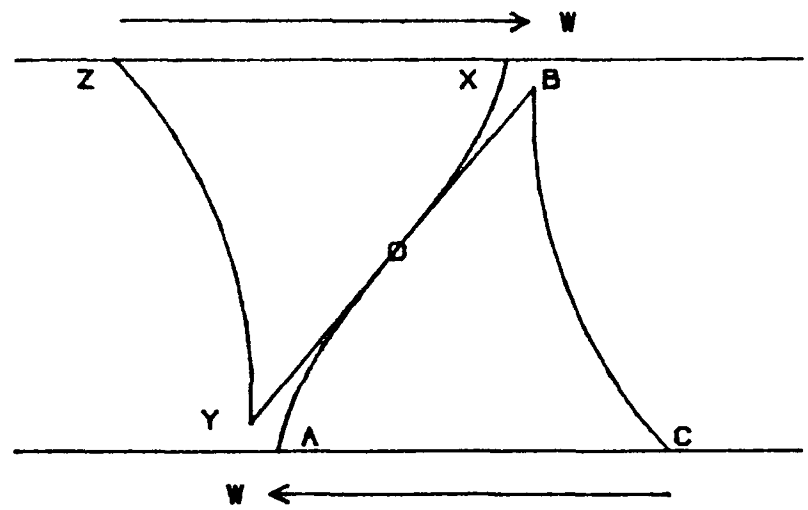
3.7 Pressure Flank Load Distribution

A pressure flank load distribution and application method was needed for the mathematical thread joint model that would reflect real world behavior and conform in principle to the leading accepted load distribution theories of Sopwith and Heywood. In addition, this method was required to handle loading of a variety of non-conforming thread conditions. The resulting method represents an approximation to actual thread loading phenomena and does not attempt to quantify the effects of surface hardness and finish, friction, non-axial loading, non-parallel pressure flank surfaces, residual stress, and other factors involved in the overall thread loading mechanism.

According to Sopwith (5), the screw thread on each component can be considered as a short, very wide cantilever, the width being the total length of the thread measured along the helix. The method of load application is shown in Figure 3.7.1. The cantilevers ABC and XYZ in Figure 3.7.1a are intially in contact over the their entire length, but when load W is applied, the cantilevers deform as shown in Figure 3.7.1b. Sopwith contends that by symmetry, the load will be concentrated at the center O of the two cantilevers; the inner parts AO and OX will bend as shown, the unloaded outer parts remaining straight and in line (BOY). Sopwith further asserts that, "In practice the load will be distributed over a narrow band, such that the pressure is of the order of the Brinnell hardness of the material, and even at failure the width of this band will not exceed about 1/10th the length AB



(a)



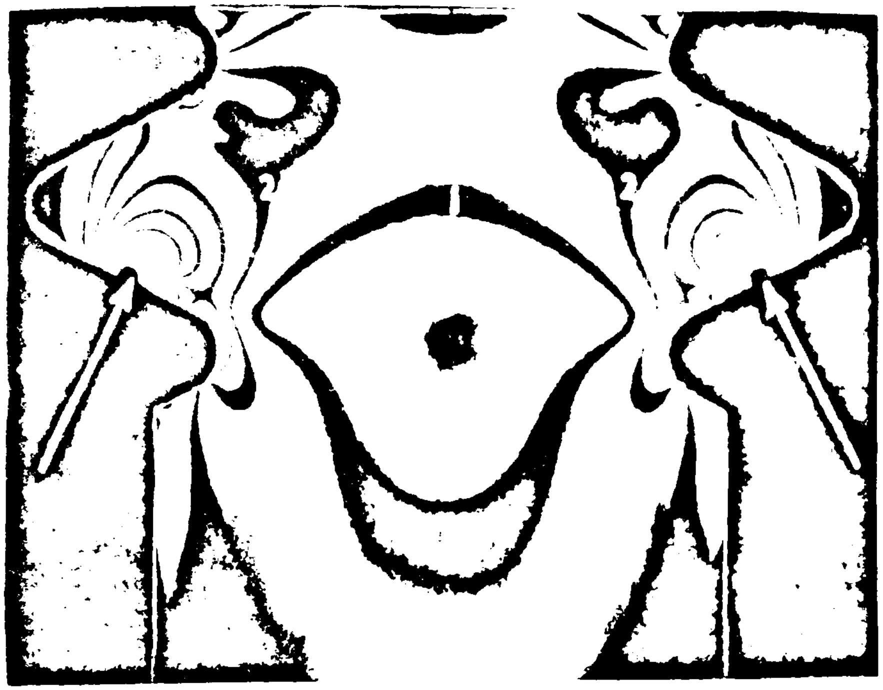
(b)

FIGURE 3.7.1 APPLICATION OF LOAD TO SCREW THREAD (SOPWITH).

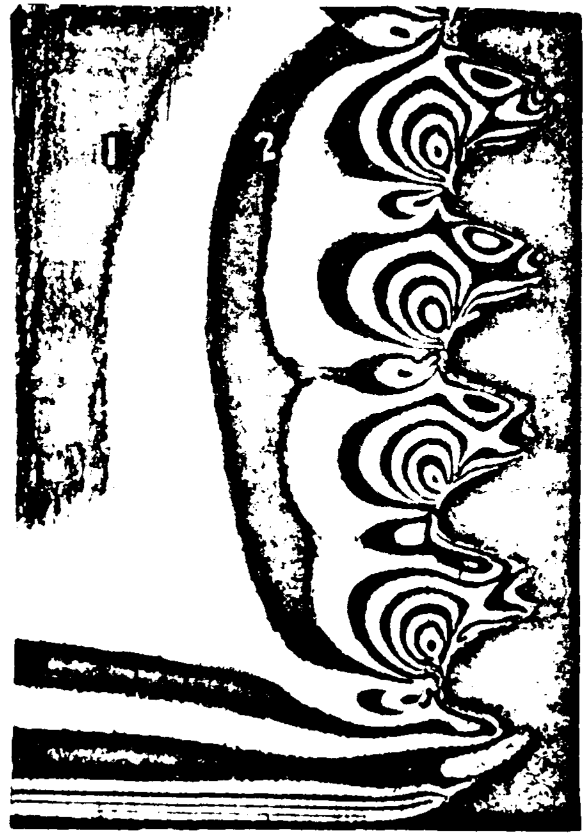
or XY (depth of engagement of thread) and may be taken as concentrated. In the screw thread case, the mean width of the two 'cantilevers' is slightly different, and the load will be concentrated not at mid-depth, but very slightly nearer the root of the male thread." To condense Sopwith's analysis, the thread loading is a point load (possibly a small distribution) acting very near the center of the thread depth.

Heywood (18), presents two-dimensional photoelastic analysis of thread joints under single point loads having different orientations and simulated thread-to-thread contact loads. In comparing the two photographs of Figure 3.7.2, they both exhibit some similar tendencies in the relative locations and magnitude of stresses, except at the contact surfaces where some obvious differences are noted. The interference bands indicating the stress contours in Figure 3.7.2a show a concentrated high stress from which circular bands emulate. However, in Figure 3.7.2b the simulated thread-to-thread contact shows an elongated stress contour roughly parallel to the pressure flank surface, a marked departure from the point load photograph. The contour appears to be a slightly lop-sided parabolic shape with the axis located approximately at the center of the thread depth.

Before proceeding with developing a non-uniform load distribution, the uniform load distribution using seven point loads proposed by O'Hara (20) was studied for possible application to this effort. In our opinion, the



(a) STRESS PATTERN ON THREAD PROJECTION
HAVING CONCENTRATED LOAD



(b) STRESS PATTERN ON PLANE MODEL
THREADED JOINT

FIGURE 3.7.2 PHOTOELASTIC STRESS PATTERNS OF THREAD PROJECTION.

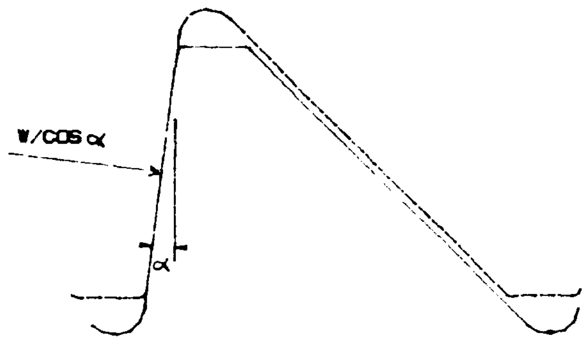
uniform represents a significant step towards a more realistic modelling of thread loading phenomena. In view of results of Sopwith and Heywood, discussed above, however, the authors of this effort have elected to augment the loading proposed by O'Hara in two ways: (1) Use non-uniform distribution and (2) limit the distribution to only the central portion of the pressure flank contact area. Figure 3.7.3 provides a comparison of the different load distributions being considered.

The thread load distribution system adopted for our model is shown in Figure 3.7.4. The distribution is assumed to be parabolic (using seven point loads) and is centered about the center of the thread depth (load diameter) defined by equation 3.7.1. The parabolic distribution is assumed to act

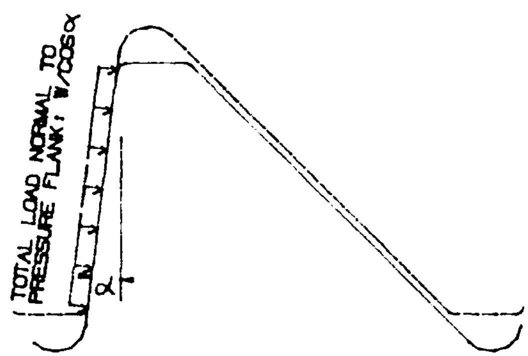
Load Dia = (Min Major Dia Ext Thrd - Max Minor Dia Int Thrd)/2 (3.7.1)

over 40% of the total thread surface contact area to roughly approximate the distribution shown in Figure 3.7.2b and to allow a 30% thread contact area on either sides to accommodate contact variations caused by non-conforming thread dimensions for the external thread major and internal thread minor diameters.

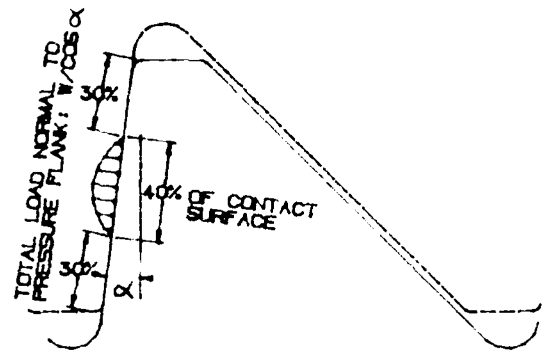
The form of the parabolic distribution shown in Figure 3.7.4 is defined by equation 3.7.2, where the seven point loads along the distribution are calculated by the ratio of the area of a given section divided by the total



(A) CONCENTRATED LOAD DISTRIBUTION.
(HEYWOOD & SOPWITH)



(B) UNIFORM LOAD DISTRIBUTION.
(O'HARA)



(C) PROPOSED PARABOLIC
LOAD DISTRIBUTION.

FIGURE 3.7.3 LOAD DISTRIBUTIONS ON PRESSURE FLANK.

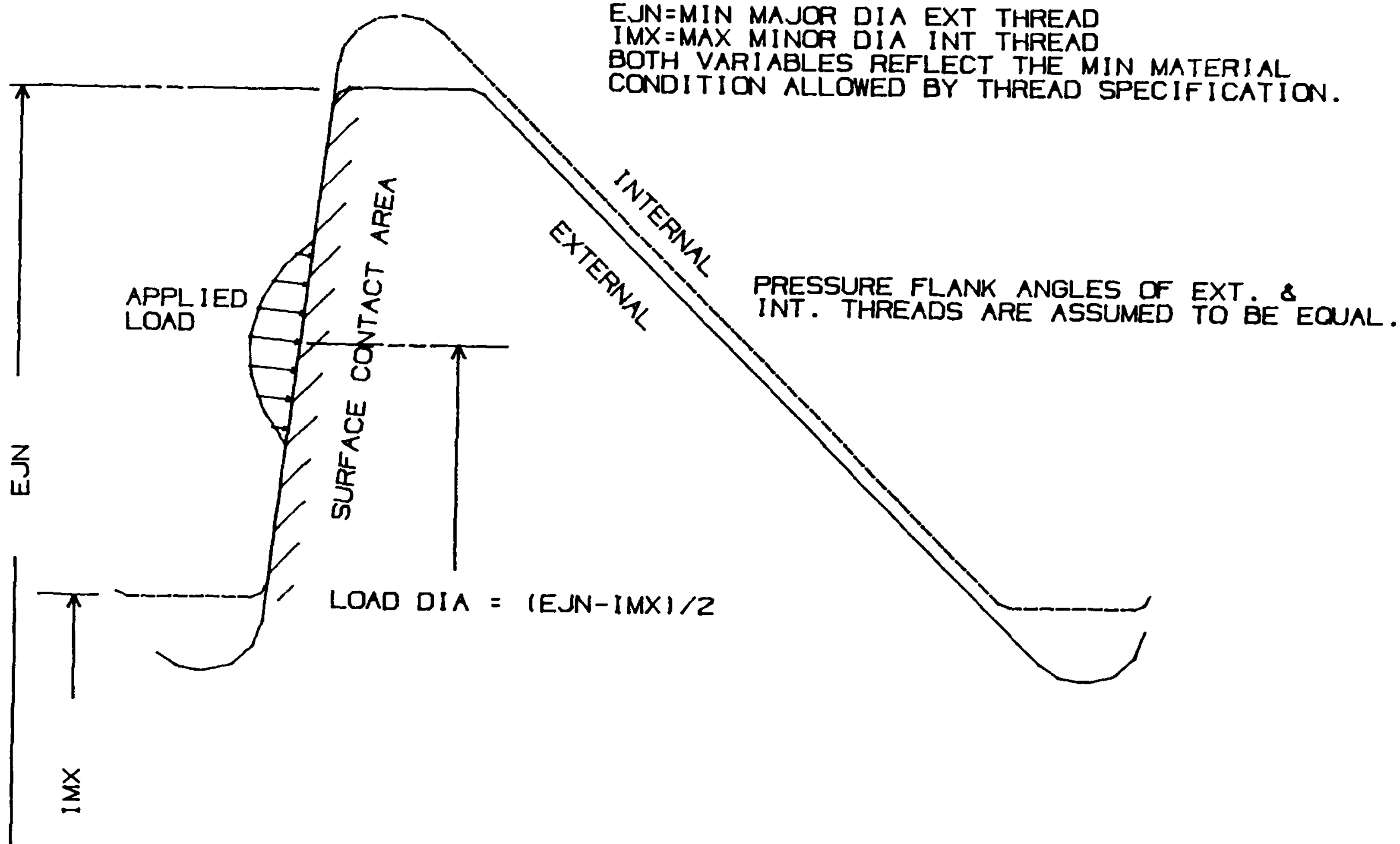


FIGURE 3.7.4 LOCATION OF LOAD DIAMETER.

area under the parabola. Equation 3.7.3 provides the expression for the load magnitudes of each section. Equation 3.7.4 expresses the location of the centroid of each section where the equivalent load is assumed to act.

$$y = \frac{(4u^2 - x^2)}{4u} \qquad (3.7.2)$$

where: $u = .1 \dfrac{\text{Min Major Dia (external) - Max Minor Dia (internal)}}{\text{2 Cos(Pressure Flank Angle)}}$

$$W_n = W \frac{\text{Area of Section n}}{\text{Total Area}} = W \frac{\int_{b_n}^{a_n} y\,dx}{\int_{-2u}^{2u} y\,dx}$$

$$W_n = W \frac{\int_{b_n}^{a_n} (u - x^2/4u)\,dx}{\int_{-2u}^{2u} (u - x^2/4u)\,dx} \qquad (3.7.3)$$

$$\bar{x}_n = \frac{\int xy\,dx}{\int y\,dx} = \frac{\int_{b_n}^{a_n} (ux - x^3/4u)\,dx}{\int_{b_n}^{a_n} (u - x^2/4u)\,dx} \qquad (3.7.4)$$

where: W = Total applied load to thread joint

W_n = Portion of load applied to section n

a_n & b_n = X-axis boundaries of section n

Calculated results obtained from the above equations are given in the following table:

Table 3.7.1 Calculated Load Distribution Parameters

Section No	Section Area	Load Value	Location from center
1	$.1477\ u^2$	.0554 W	- 1.6241 u
2	$.3809\ u^2$	.0554 W	- 1.1197 u
3	$.5209\ u^2$	.1953 W	- .5629 u
4	$.5675\ u^2$	.2128 W	0
5	$.5209\ u^2$	.1953 W	.5629 u
6	$.3809\ u^2$	.1428 W	1.1197 u
7	$.1477\ u^2$	.0554 W	1.6241 u

3.8 Combined Loading

Both axial loads and thread loads produce fillet stresses in the thread root area. As indicated in Figure 3.8.1, the axial loads cause concentration of stress at the bottom of thread roots (points c and c'); while thread loads cause stress concentration at approximately 30 degrees to pressure flank (point A), and compressive stress at approximately 30 degrees to clearance flank (point B). The magnitude of tensile fillet stress is usually much larger than that of compressive fillet stress. The angle between fillet stress due to axial load and tensile fillet stress is $(60-\alpha)$, where α is the pressure flank angle in degrees. Combined loading will produce a maximum fillet stress which is considered a major factor of thread failure.

Notched parts subjected to bending or axial loads often experience a biaxial stress at the surface of the notch. A threaded connection in tension sees a tangential or a circumferential tensile stress in the notch, in addition to the primary axial stress. Peterson (21) has considered the influence of this biaxial stress factor, as assessed by the distortion energy theory of failure. Addition of the primary and secondary principal stresses, which have the same sign, reduces the energy of distortion. The biaxial effect is a favorable one which lowers the effective stress concentration factor to an estimated maximum of 15% lower than the regular stress concentration factor.

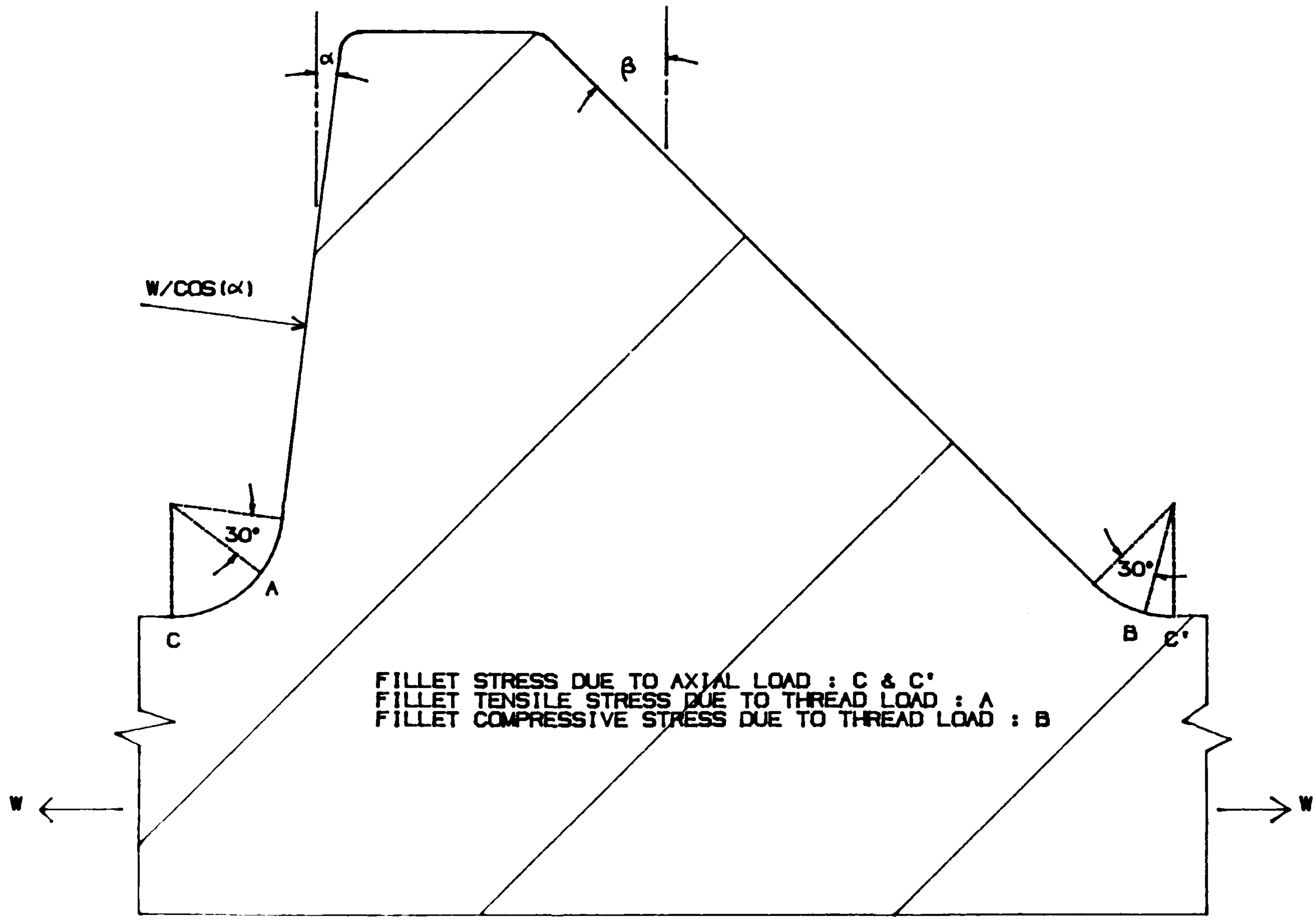


FIGURE 3.8.1 LOCATIONS OF MAXIMUM FILLET STRESSES DUE TO AXIAL LOAD & THREAD LOAD.

Tangential (hoop) stress at the thread root area should be included in the thread stress analysis, as in the case of the cannon breech mechanism where the threaded connections are subjected to internal pressure. Consider a thick wall cylinder with inside radius (ri) and outside radius (ro), which is subjected to an internal pressure (pi). The radial stress (Sr) and tangential stress (Sh) can be expressed as

$$Sr(r)=Kh\ (1-(ro/ri)^2) \qquad (3.8.1)$$

and

$$Sh(r)=Kh\ (1+(ro/ri)^2) \qquad (3.8.2)$$

where $Kh=(pi)(ri)^2/((ro)^2-(ri)^2)$, r is the radius varying from ri to ro. At outside surface of the thick wall cylinder r=ro, the radius stress and tangential stress become

$$Sr(ro)=0 \qquad (3.8.3)$$

and

$$Sh(ro)=2(pi)(ri)^2/((ro)^2-(ri)^2) \qquad (3.8.4).$$

The tangential stress at external thread root area can be estimated by the equation

$$Sh=2(pi)(d)^2/((Kemin)^2-d^2) \qquad (3.8.5)$$

where d is hollow diameter and Kemin is minimum minor diameter of the external thread. If preload is applied on the threaded connection, the tangential stress for internal thread at the thread root area can be estimated by simulating the threaded connection as concentric cylinders with an interference fit. Since the loading condition of internal pressure is two-dimensional, only plane stresses will be involved. The tangential stress can be superimposed with fillet stresses due to axial load and thread load.

The actual magnitudes of combined stresses due to axial load, thread load and internal pressure at any point along the thread root boundary are extremely difficult to assess for they depend on the complicated distortions and strains occurring in the two threaded members. However, photoelastic data show that the tensile fillet stress is the dominating component in the combined loading effects. The maximum fillet stress is observed in between bottom of the thread root and point A, 30 degrees to pressure flank, and very close to point A. Figure 3.8.2 shows the combined effect of fillet stresses. The dotted line DEF represents the distribution of tensile fillet stress due to thread load (along the boundary of thread root) and has its maximum value at point A. The dotted line FGH represents the distribution of compressive fillet stress due to thread load and has its maximum value in magnitude at point B. Similarly, dotted line IJK represents distribution of tensile fillet

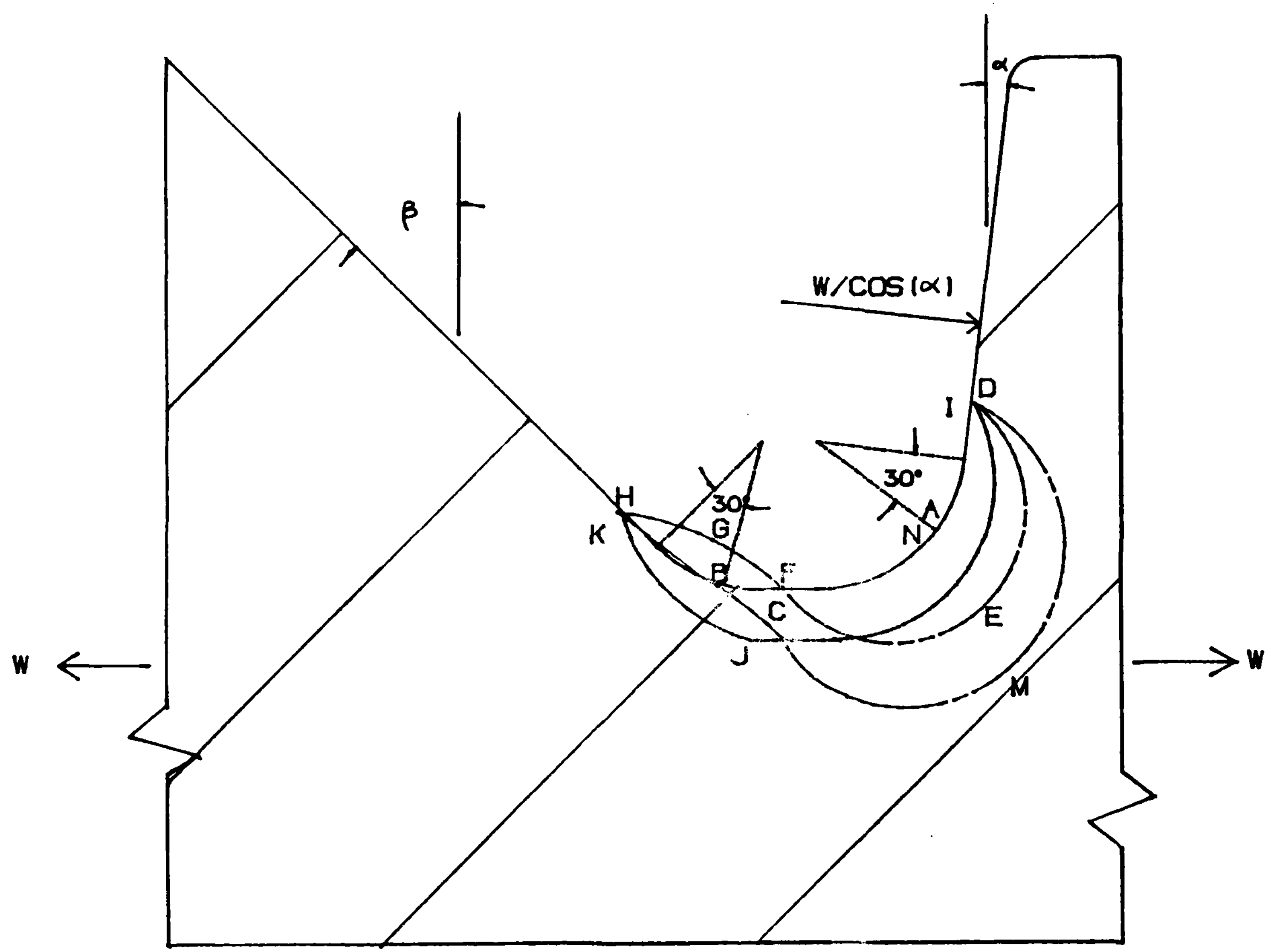


FIGURE 3.8.2 COMBINED FILLET STRESSES ON FILLET CONTOUR.

stress due to axial load having its maximum value at point C. By adding the three stresses at points along the thread root boundary, an estimate is obtained for the stress distribution due to the combined effect, which is represented by chain dotted line HMD having a maximum value at point N and very close to point A. For simplicity, it is assumed that the maximum value of the combined effect takes place at point A. The maximum combined stress, obviously, is not equal to the algebraic sum of maximum values due to separately applied loads.

On the boundary of the thread root, stresses normal to fillet contours are zero, and there are no shear stresses on free contour surface. Therefore, the combined fillet stress at point A is a principal stress which is tangent to the fillet contour, and takes the form

$$Sc=Sb+St(60-\alpha) \qquad (3.8.6)$$

where Sb is the maximum fillet stress due to thread load and $St(60-\alpha)$ is the fillet stress due to axial load at point A. Including tangential (hoop) stress Sh, the state stress at point A is shown in Figure 3.8.3. The hydrostatic tension and pure shear on octahedral plane can be written, respectively, as

$$Soct=(1/3)(Sb+St(60-\alpha)+Sh) \qquad (3.8.7)$$

and

$$Toct=(1/3)(Sb+St(60-\alpha)-Sh) \qquad (3.8.8) .$$

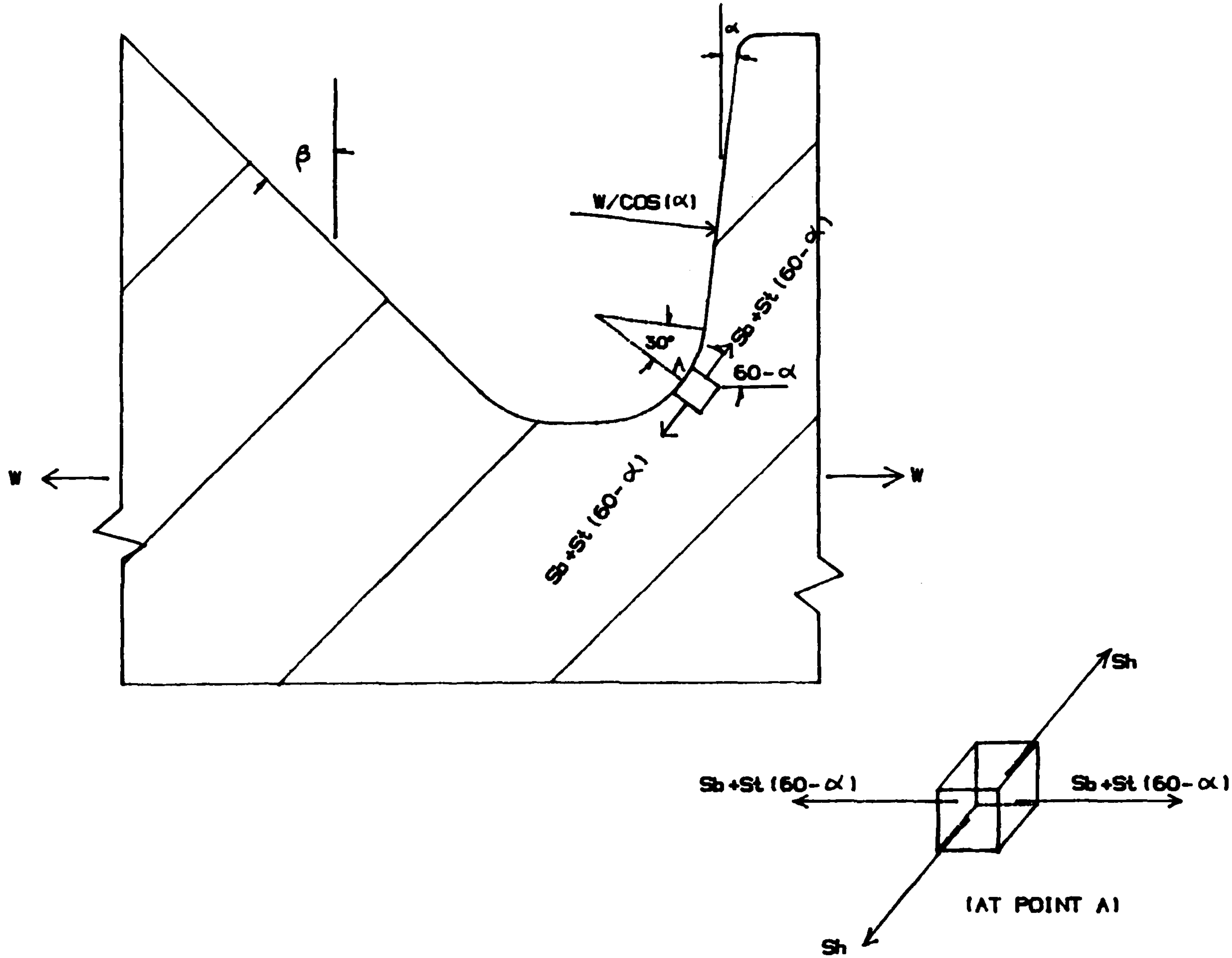


FIGURE 3.8.3 THE STATE OF STRESS AT LOCATION OF MAXIMUM FILLET STRESS DUE TO COMBINED LOADING.

Under the static loading condition, the safety factors of the threaded connection due to triaxial tensile fillet stress are defined as

$$Ny=Sy/Soct \qquad (3.8.9)$$

and

$$Nu=Su/Soct \qquad (3.8.10)$$

where Ny and Nu are safety factors referring to yield stress and ultimate strength, respectively. Similarly, if the maximum distortion energy theory is applied, safety factors of the threaded connection due to triaxial shear fillet stress are defined as

$$Ny=0.577Sy/Toct \qquad (3.8.11)$$

and

$$Nu=0.577Su/Toct \qquad (3.8.12) .$$

3.9 Fatigue

The most frequent failure mode of the threaded connections is fatigue failure due to maximum fillet stresses at the thread root area. Fatigue strength is, therefore, a main concern of design criterion for the thread connection.

To establish the fatigue strength of a material, several tests are necessary because of the statistical natural of fatigue. Through a series of fatigue tests, a S-N (fatigue strength vs. fatigue life cycle) diagram is obtained. Figure 3.9.1 shows an example S-N curve generated on log-log paper for a steel part. The graph shows a knee beyond which no failure will occur regardless of how great the number of cycles. The strength corresponding to the knee is called endurance limit Se, or fatigue limit. The graph never becomes horizontal for nonferrous metals and alloys and hence these materials do not have an endurance limit. Experimental data show that the endurance limit ranges from 40% to 60% of tensile strength (Su) for steel up to Su=200 ksi with mean endurance limit Se'=0.5Su. For tensile strength of 200 kpsi and over, the mean endurance limit is 100 kpsi.

The endurance limit (Se) of a machine element such as threaded connection may be affected by geometric and enviormental factors. The major factors are size effect (Cd), surface finish effect (Cs), effect of load type (Cl),

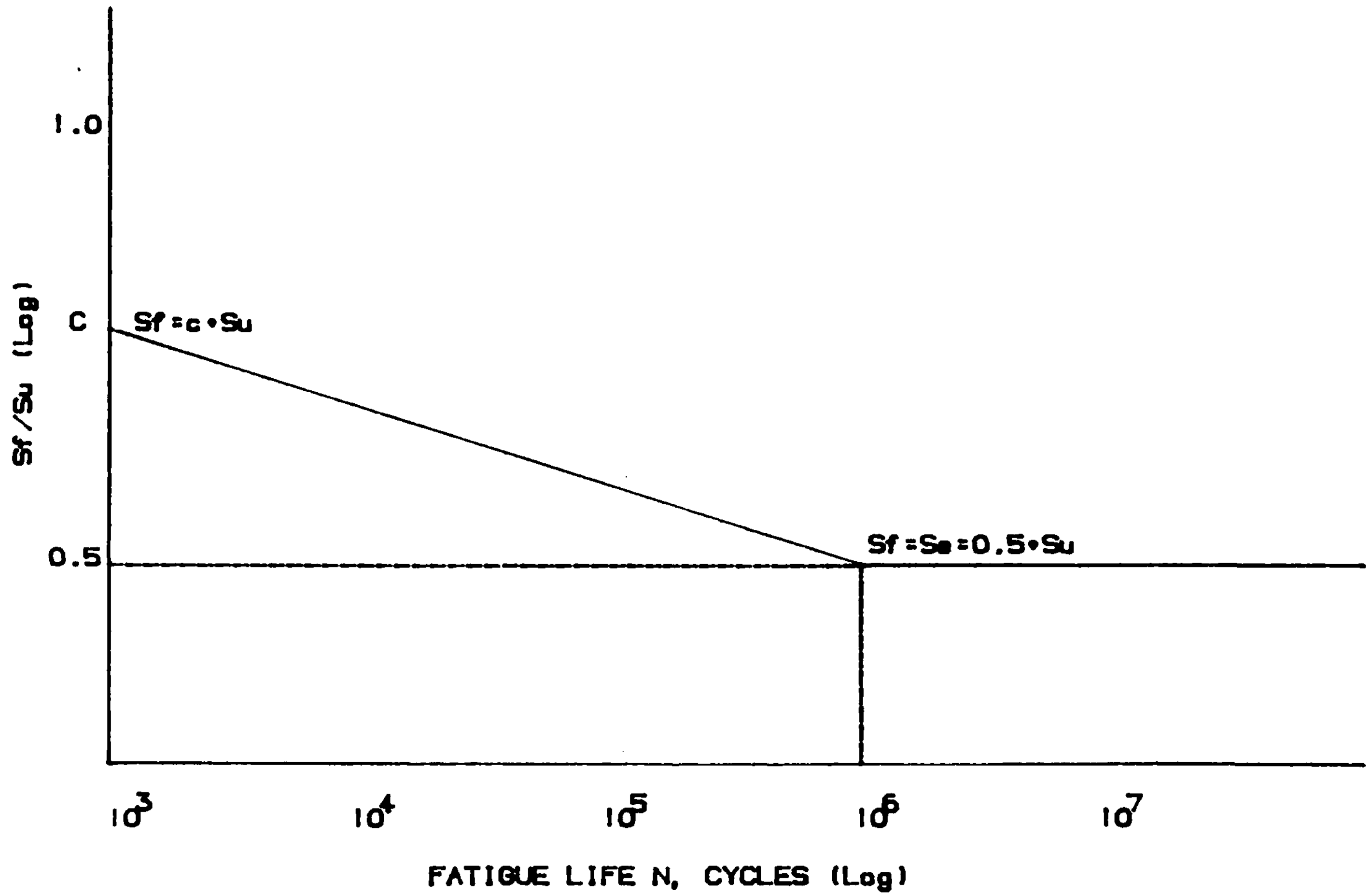


FIGURE 3.9.1 GENERALIZED S-N DIAGRAM.

modifying factor due to fatigue stress concentration (Ck), temperature effect (Ct) and reliability factor (Cr). The modified endurance limit may be written as

$$Se=CdCsClCkCtCrSe' \qquad (3.9.1).$$

The size effect is generally believed to be related to the stress gradient. For bending and torsion Cd is selected as follow:

$$\begin{array}{ll} Cd=1 & D \leq 0.4'' \\ Cd=0.85 & 0.4'' < D \leq 2'' \\ Cd=0.75 & D > 2'' \end{array} \qquad (3.9.2)$$

where D is major diameter of the threaded connection. And for axial load Cd=1.

Surface finish of a part may affect its endurance limit in three ways: (1) by introducing stress concentration resulting from surface roughness, (2) by altering the physical properties of the surface layer of the material, e.g., an as-forged surface is not only rough but also decarburized, and the decarburization decreases the strength of the surface layer, and (3) by introducing residual stresses, e.g., grinding operations often leave the surface layer in residual tension and thereby reduce its ability to withstand reversed loading. The surface finish effect Cs is defined as the ratio between the endurance limit obtained with arbitrary surface finish and that obtained with the standard Moore mirror-polished finish as shown in Figure 3.9.2.

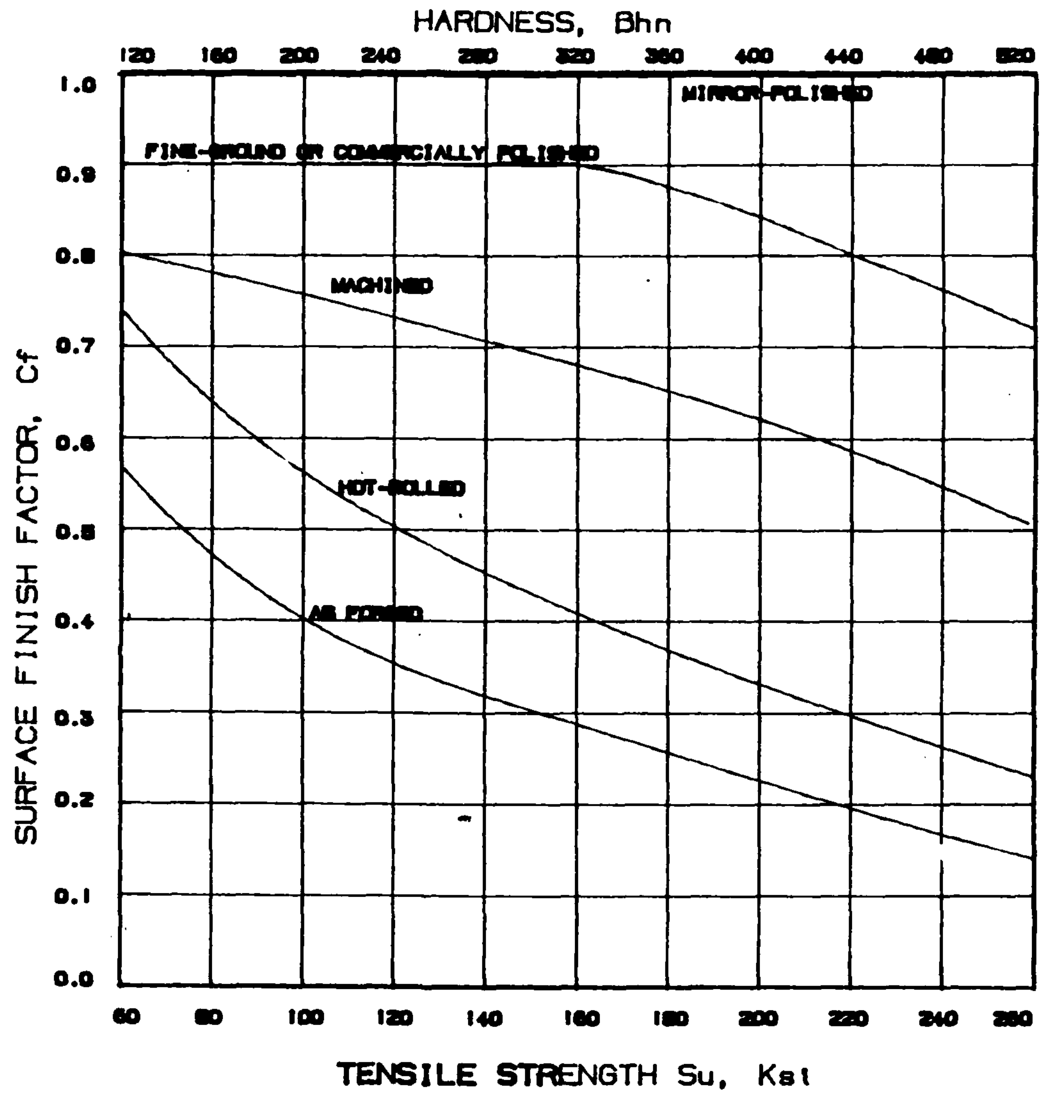


FIGURE 3.9.2 REDUCTION OF ENDURANCE STRENGTH DUE TO SURFACE FINISH FOR STEEL PARTS.

According to Juvinall (14), the endurance limit at 10^6-cycle strength for various load types may, in absence of specific test data, be approximated by multiplying the standard mean endurance limit Se' by the following load constants (Cl):

Reversed or rotating bending: Cl=1.0

Reversed axial loads: Cl=0.9 without bending,

Cl=0.6 to 0.85 with indeterminate bending

Reversed torsion: Cl=0.58 ductile metals,

Cl=0.8 cast iron (and most brittle materials).

Stress concentration is a highly localized effect. The high stresses actually exist in only very small region in the vicinity of the discontinuity such as fillet, notch and crack. In the case of ductile materials the first load applied to the member will cause yielding at the discontinuity which relieves the stress concentration. Thus when the parts are made of ductile materials and the loads are static, it isn't necessary to use a stress concentration factor. However, when parts are made of brittle materials or when they are subject to fatigue loading , then the stress concentration to be considered. Fatigue stress concentration factor Kf is defined as a ratio between endurance limit of notch free specimen and endurance limit of notched specimen. This factor can be expressed in terms of notch sensitivity q and stress concentration factor Kt, such that

$$Kf=1+q(Kt-1) \qquad (3.9.3)$$

where $0 \leq q \leq 1$. If $q=0$, $Kf=1$, the material has no sensitivity to notches at all. If $q=1$, $Kf=Kt$, the material has full sensitivity to notches. Figure 3.9.3, provided by R. E. Peterson (21), shows a family of curves of notch sensitivity q with respect to notch radius r for various steel tensile strengths. For a typical unified and American standard thread steel bolt subjected to bending or axial loading, the fatigue stress concentration factor Kf is estimated as follow:

Annealed (less than 200 Bhn): Kf=2.2 (rolled), Kf=2.8 (machined)

Quenched and drawn(over 200 Bhn): Kf=3.0 (rolled), Kf=3.8 (machined).

The modifying factor for stress concentration is defined as $Ck=1/Kf$. According to Heywood (13), fatigue stress concentration factor for finite life (Kf') ranges from 1 to Kf, where $(Kf'-1)/(Kf-1)$ is fairly linearly proportional to ultimate tensile strength (Su) as shown in Figure 3.9.4. In this report, the estimated safety factor for simple cyclic loading at various finite life cycles (N), Kf' is assumed to be linearly proportional to Log(N).

The temperature effect is considered when the machine elements are operated under high temperature enviroment. For ferrous metals the temperature effect (Ct) is estimated to be:

$$Ct=620/(460+T) \qquad \text{When } T > 160^{\circ}F$$
$$Ct=1 \qquad \text{When } T <= 160^{\circ}F \qquad (3.9.4).$$

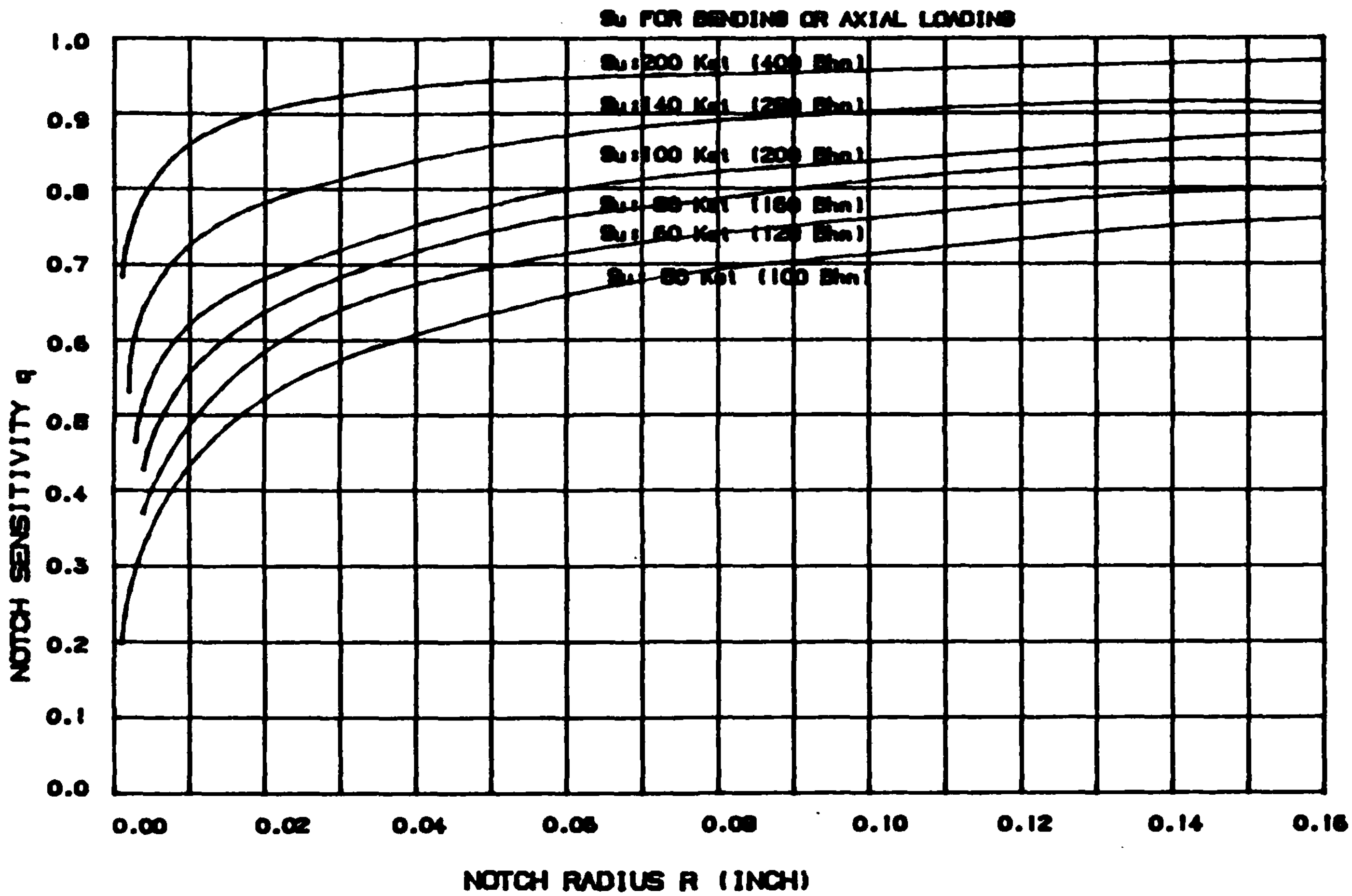


FIGURE 3.9.3 NOTCH SENSITIVITY CURVES FOR STEEL PARTS.

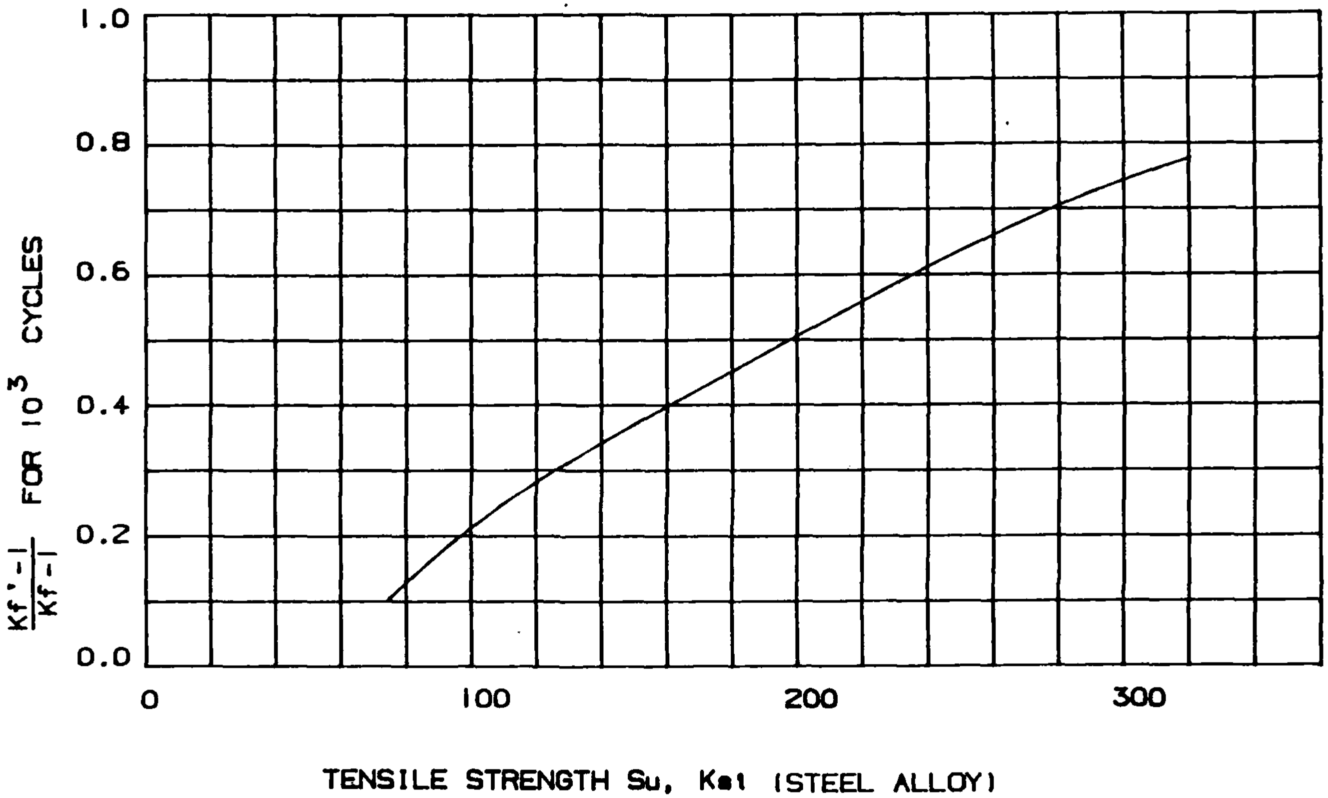


FIGURE 3.9.4 FATIGUE STRESS CONCENTRATION FACTOR FOR FINITE LIFE Kf' AT 10^3 CYCLES (HEYWOOD (13)).

Table 3.9.1 Reliability factor Cr

Reliability R	Standardized variable Zr	Reliability factor Cr
0.50	0.	1.000
0.90	1.288	0.897
0.95	1.645	0.868
0.99	2.326	0.814
0.999	3.091	0.753

In estimating the S-N diagram for ferrous metals, the endurance limit Se, plotted at 10^6 cycles on log-log coordinates, is connected by a straight line with the estimated fatigue strength (Sf=cSu) at 10^3 cycles. For bending and torsional load, the constant c is estimated to be 0.9, and for axial loads, c ranges from 0.75 to 0.9. The straight line can be used to define the mean fatigue strength Sf corresponding to any fatigue life N, where $10^3 < = N < = 10^6$, The line equation can be written as

$$\log Sf = -m \log N + b \qquad (3.9.6)$$

where

$$m = (1/3)\log(cSu/Se) \qquad (3.9.7)$$

and

$$b = \log((cSu)^2/Se) \qquad (3.9.8).$$

This line intersects 10^6 cycles at Se and 10^3 cycles at cSu in logS-logN

curve. When Su and Se are given, parameters m and b can be solved. Then if fatigue life N is given, the corresponding fatigue strength Sf can be calculated through the following relation:

$$Sf=10^{b}/N^{m} \quad , \quad 10^{3} <= N <= 10^{6} \qquad (3.9.9).$$

Alternatively, if the fatigue strength Sf is given, the fatigue life N can be found as

$$N=10^{b/m}/Sf^{1/m} \quad , \quad 10^{3} <= N <= 10^{6} \qquad (3.9.10).$$

For the loading history, fluctuating stresses are presented in terms of maximum stress Smax (or Tmax for torsion), minimum stress Smin (or Tmin), mean stress Sm (or Tm), alternating stress Sa (or Ta) and prestress Sp (or Tp). The mean stress and alternating stress can be expressed as

$$Sm=Sp+(Smax+Smin)/2 \qquad (3.9.11)$$

and

$$Sa=(Smax-Smin)/2 \qquad (3.9.12).$$

A few criteria for fatigue fracture are presented in the literatures such as Soderberg line, Goodman line, Gerber parabola, Sine octahedral approach and Kececioglu curve. Figure 3.9.5 shows a typical Sa-Sm diagram with test data and various fatigue fracture criteria with respect to the endurance limit. The Sine octahedral approach cannot be illustrated except for special cases. These proposals, each having their particular degree

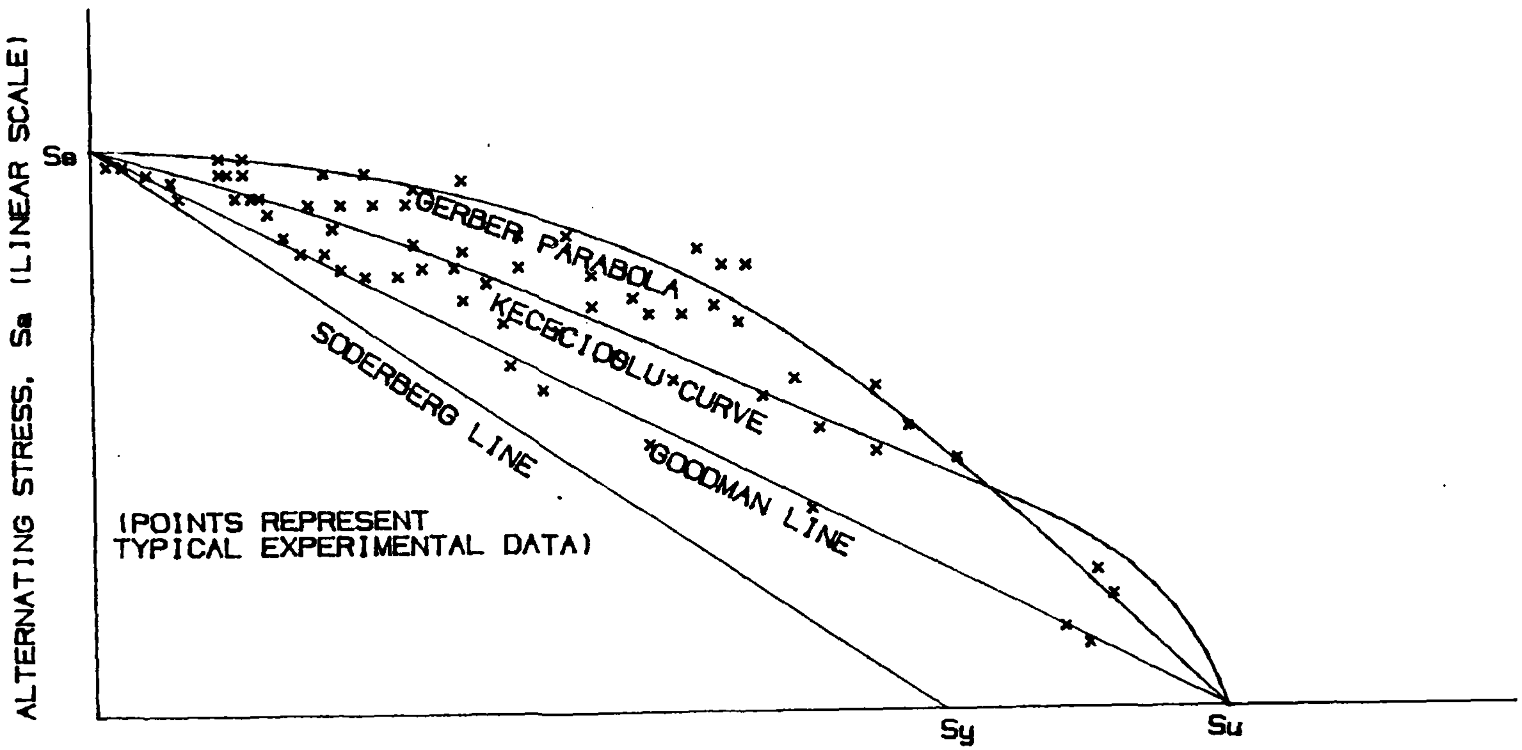


FIGURE 3.9.5 PROPOSED FATIGUE FRACTURE CRITERIA ON Sm-Sa DIAGRAM.

of conservatism, are verified by many experiments. Modified Goodman, a conservative criterion of fatigue fracture, is applied in this threaded connection stress analysis. For notched specimens of ductile metals, a typical Sm-Sa (or Tm-Ta) diagram for tensile, bending or torsional loads is shown in Figure 3.9.6. The fatigue strength can be the endurance limit, corresponding to 10^6 cycles of infinite fatigue life, or any fatigue strength corresponding to fatigue life in between 10^3 cycles and 10^6 cycles. The line AB, Goodman line, is the criterion of fatigue fracture. The lines CD and CE are the criteria of static yielding. The line AF is the criterion of fatigue fracture in compression. The equation of lines AB, CD, CE and AF can be written as:

$$Sa+(Sf/Su)Sm=Sf \qquad (3.9.13)$$

$$Sm+Sa=Sy \qquad (3.9.14)$$

$$Sa-Sm=Sy \qquad (3.9.15)$$

and

$$Sa=Sf \qquad (3.9.16)$$

where Sf, Su and Sy are known positive values. All points below EFAGD correspond to fluctuating stresses which should cause neither fatigue fracture nor plastic deformation. If a machine element such as the threaded connection subjected to cyclic tensile loads and ratio Sa/Sm can be calculated, without fatigue test one can estimate fatigue strength corresponding to desired fatigue life or estimate fatigue life for a given loading condition by using

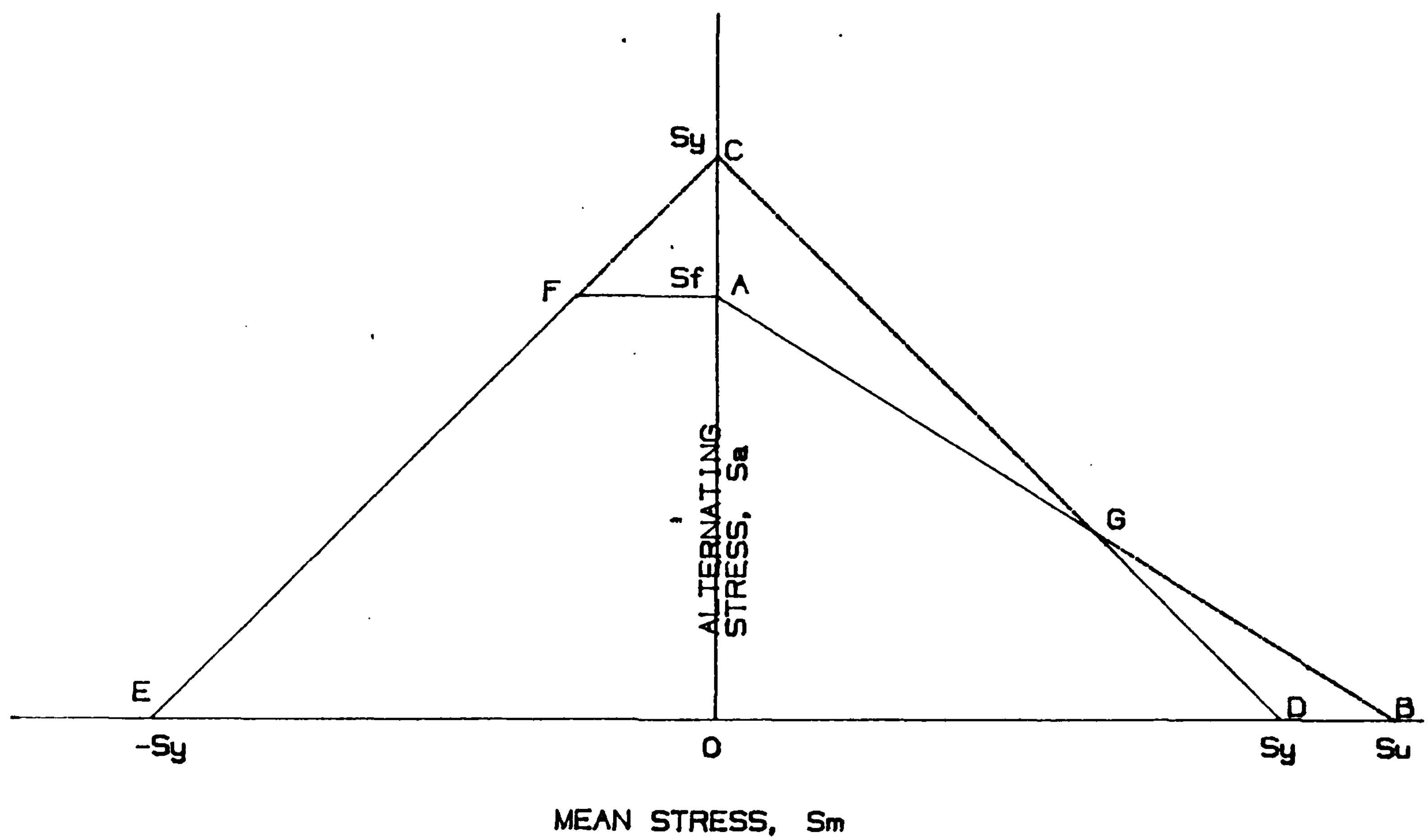


FIGURE 3.9.6 Sm-Sa DIAGRAM FOR DUCTILE METALS.

Figures 3.9.1 or 3.9.6. Figure 3.9.7 shows a experimental fatigue strength diagram for alloy steel with Su=125 to 180 kpsi under axial loading using Sm-Sa as well as Smax-Smin coordinates. The curves are generated by Grumman Aircraft Engineering Corp., and applicable to alloy steel as AISI 4340, 4130, 2330 and 8630 etc. The diagram shows that the fatigue strength at 10^3 cycles is about 84% of the ultimate strength. This diagram and fatigue factor of size effect (Cd), surface finish effect (Cf), load type effect (Cl), modifying factor due to fatigue stress concentration (Ck), temperature effect (Ct) and reliability factor (Cr) will be used in the program to estimate the safety factor of the threaded joint under a simple cyclic loading condition at various fatigue life cycles.

From Section 3.8, combined loading, the elements on the fillet contour have two stress components which are the hoop stress (Sh) and the combined fillet stress due to axial load and thread load (Sc). Both stresses Sh and Sc may have both mean and alternating components (Shm, Sha, Scm and Sca). By using distortion energy theory, the mean and alternating von Mises stresses are defined as:

$$S'm=(Shm^2-ShmScm+Scm^2)^{\frac{1}{2}} \qquad (3.9.17)$$

and

$$S'a=(Sha^2-ShaSca+Sca^2)^{\frac{1}{2}} \qquad (3.9.18)\ .$$

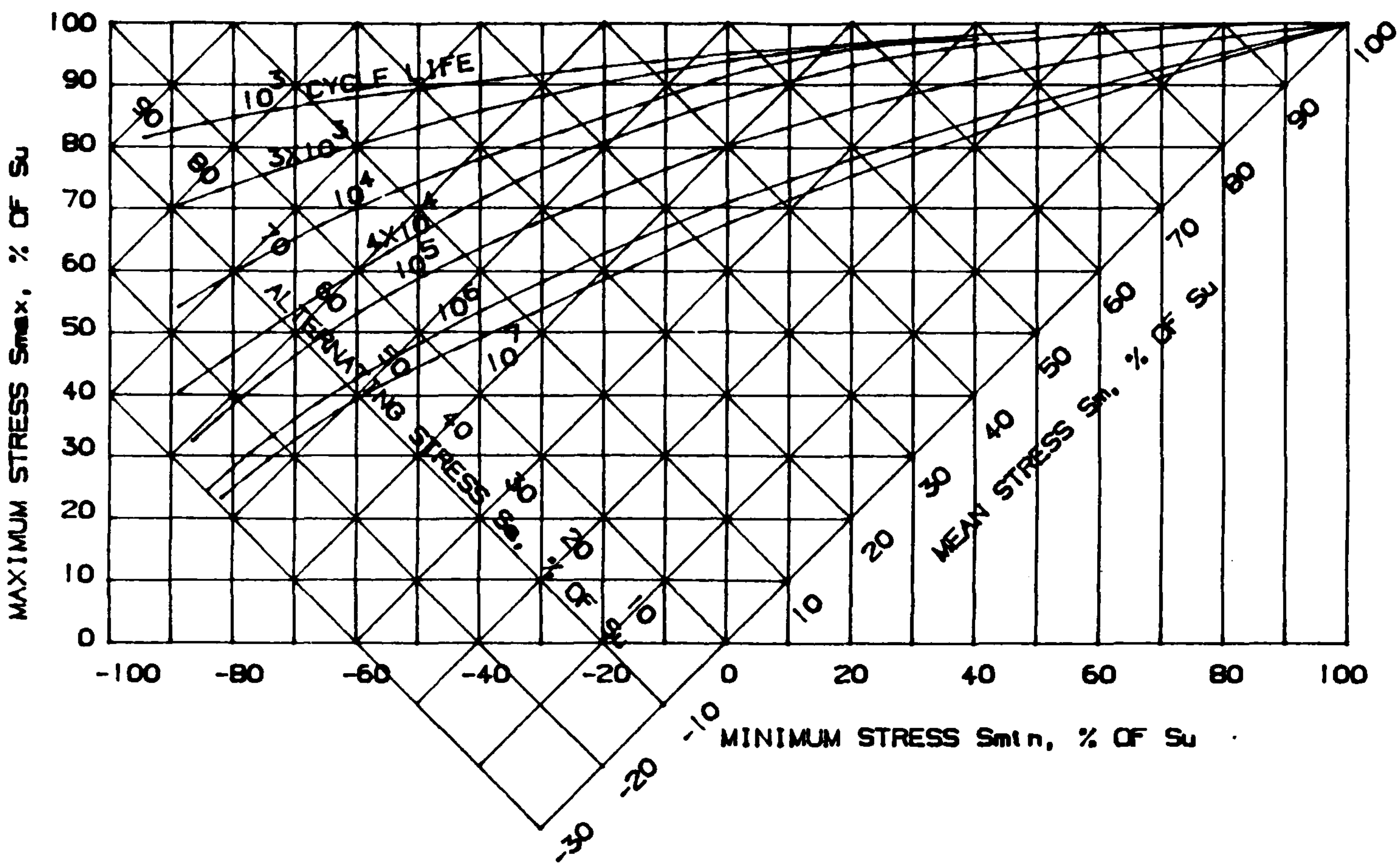


FIGURE 3.9.7 FATIGUE STRENGTH DIAGRAM FOR ALLOY STEEL, Su=125 TO 180 Ksi AXIAL LOADING. (AVERAGE OF TEST DATA FOR POLISHED SPECIMENS OF AISI 4340, 4130, 2330 & 8630) (GRUMMAN AIRCRAFT ENGINEERING CORP.)

These two stress components may then be applied to S'm-S'a diagram and fatigue criterion such as modified Goodman criterion to estimate fatigue strength or fatigue life.

The safety factor due to combination of mean and alternating stresses can be determined by Sm-Sa diagram with fatigue fracture criterion. If a threaded connection is under cyclic loads, a load line OP and nominal load point N can be establisded in Sm-Sa diagram as shown in Figure 3.9.8. The nominal load point corresponds to the combination of mean and alternating stresses. It is observed that there are three possible design overload points on the fatigue fracture criterion curve (modified Goodman line is applied in this study) of specified fatigue strength which may correspond to any fatigue lifes from 10^3 cycles to 10^6 cycles. The three interpretations, according to Juvinall (14), represented on the figure are discussed as follow:

(1) If the nature of the machine involved was such that only the alternating stress could be increased due to overload, point Q would be the design overload point, and the safety factor would be

$$Nf=OF/OD \qquad (3.9.19)$$

(2) If the mean stress, by itself, could be increased during overloading, point R would be the design overload point, and the safety factor would be

$$Nf=OC/OA \qquad (3.9.20)$$

(3) If the mean and alternating stresses increased by the same percentage during overload, point P would be the design overload point, and the

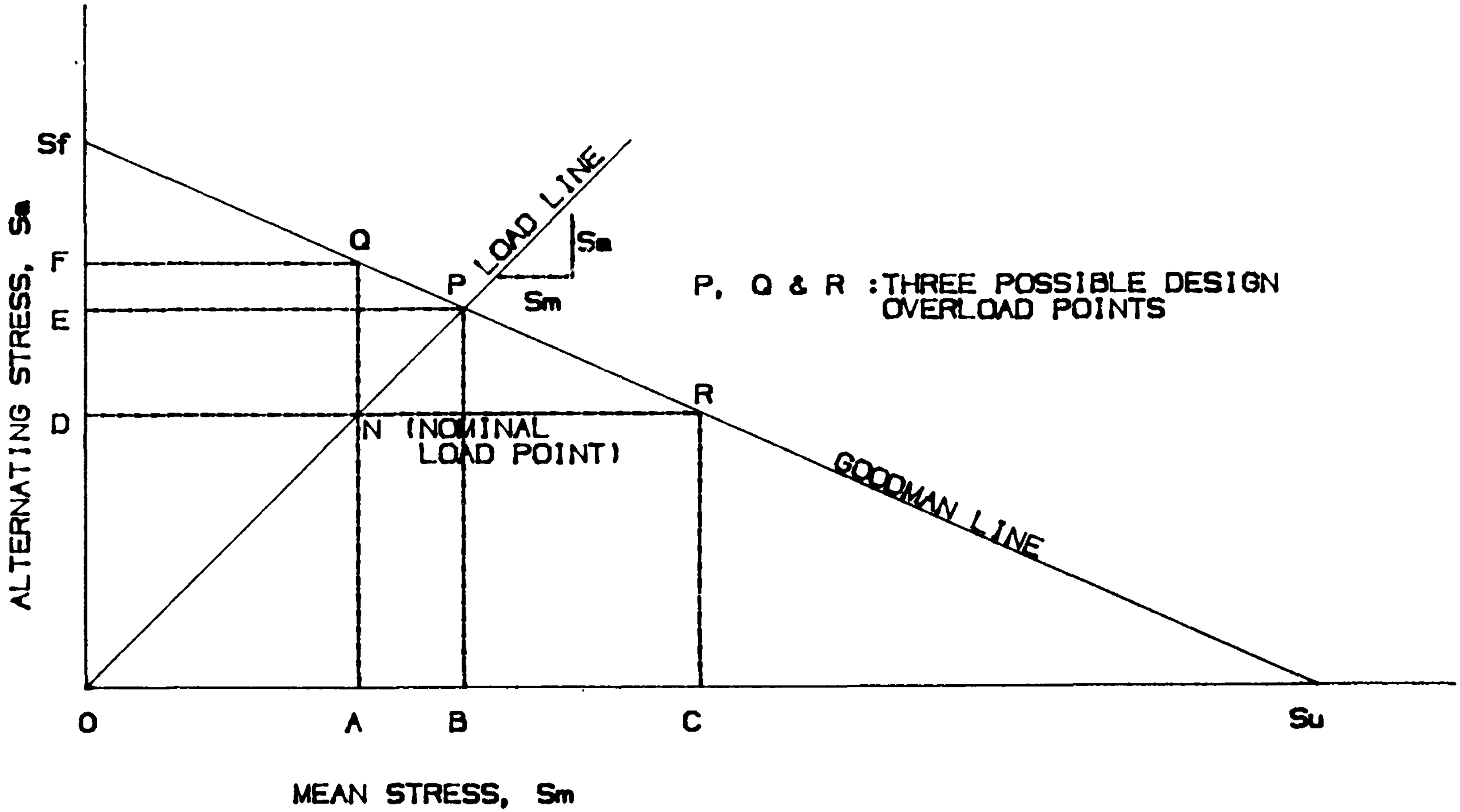


FIGURE 3.9.8 THREE POSSIBLE DESIGN OVERLOAD POINTS FOR SAFETY FACTOR CALCULATION.

safety factor would be

$$Nf=OP/ON=OE/OD=OB/OA \qquad (3.9.21)\ .$$

Without knowing nature of the machine element responding to overloading, interpretation (3) will be adopted. Figure 3.9.9 illustrates that safety factors of the nominal load point N can be calculated corresponding to fatigue lifes ranged from 10^3 cycles to 10^6 cycles, such that

$$Nf(10^6)=OB_1/OA=OC_1/OA_1=OD_1/OA_2$$

$$Nf(10^5)=OB_2/OA=OC_2/OA_1=OD_2/OA_2$$

$$Nf(10^4)=OB_3/OA=OC_3/OA_1=OD_3/OA_2$$

$$Nf(10^3)=OB_4/OA=OC_4/OA_1=OD_4/OA_2 \qquad (3.9.22).$$

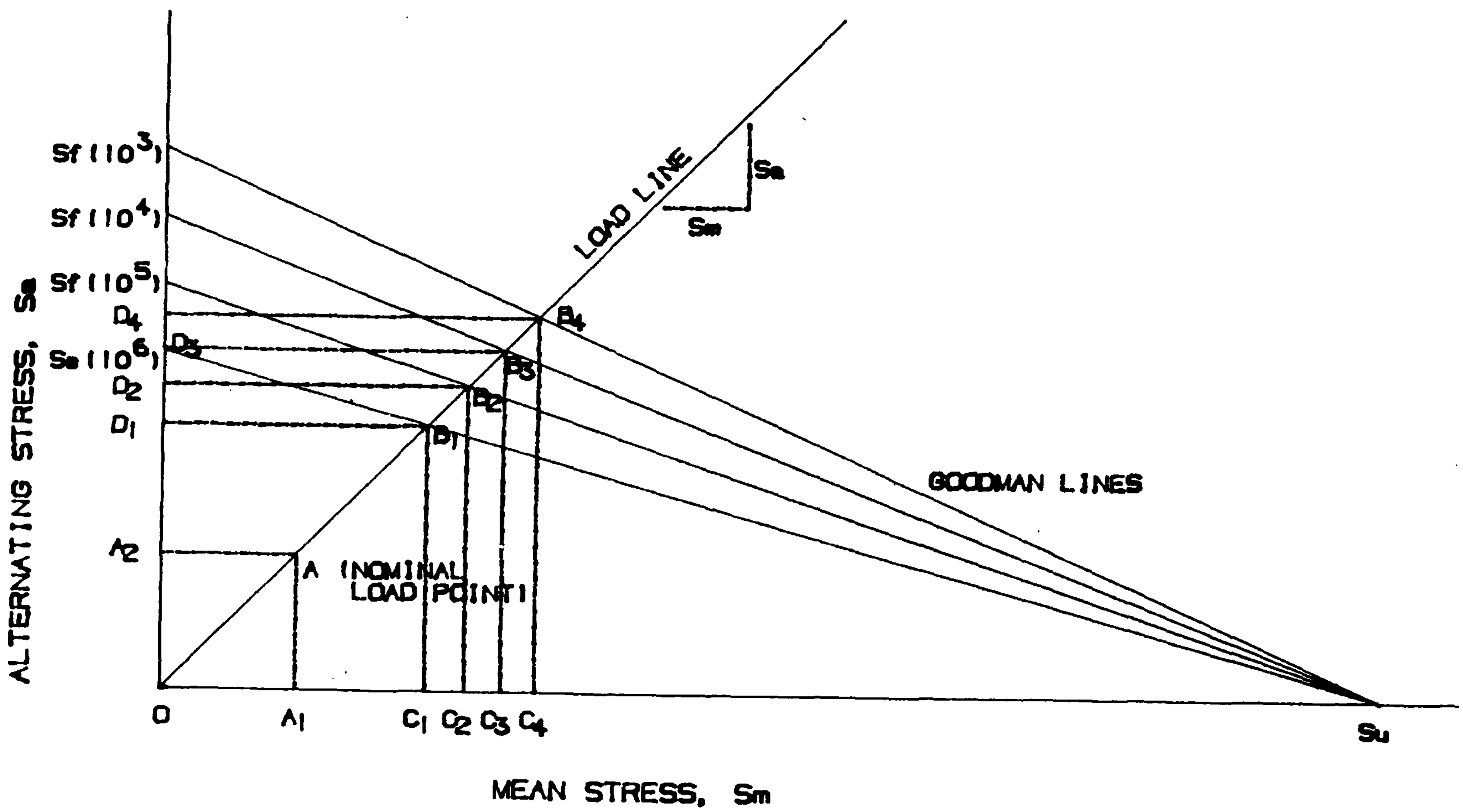


FIGURE 3.9.9 SAFETY FACTORS CORRESPONDING TO VARIOUS FATIGUE LIFE.

4. Interactive Computer Program on Thread Stress Analysis

The easy-to-use menu driven program is initiated with the command SEG THREAD which then prints the following menu on the screen:

```
*** THREAD PROGRAM CONTROL MENU ***

INTRODUCTION .................... 1
RECALL THREAD FILE .............. 2
INPUT THREAD DATA ............... 3
EDIT THREAD DATA ................ 4
LIST THREAD DATA ................ 5
SAVE THREAD DATA ................ 6
STATIC AND FATIGUE ANALYSIS ..... 7
EXIT TO PRIMOS .................. 8

ENTER:.
```

Selection of menu will guide user to prepare thread data or conduct static and fatigue analysis.

Selection of (1) INTRODUCTION will provide a brief description of the type of static and fatigue analysis that the program will perform and the types of thread forms that can be analyzed. A brief explanation of the output format and the required user provided variables is also listed.

Selection (2) RECALL THREAD FILE will prompt the user to provide a file name of a previously saved file (thread data saved by menu selection of (6)). Following user entry of a valid file name, the program reads thread data into program memory, where the data can then be listed, edited, saved, and have static and fatigue analysis applied to it.

Selection (3) INPUT THREAD DATA permits user input of thread parameters for a particular thread analysis problem. The entered data goes directly into program memory where editing, listing, saving, and analysis may be performed. Table 4.1 gives the thread stress analysis information input form which itemizes required information for thread analysis. Table 4.2 shows this information input form which has been filled in with an example.

Selection (4) EDIT THREAD DATA gives user the opportunity of changing any of the thread analysis problem parameters contained in program memory (either from input data or recalled data file). After 4 is selected, the program lists all thread parameters which are each identified with a menu number. To change any parameter, user selects appropriate thread parameter identity number and makes the change. When the editing session is over, user keys in 0 followed by a carriage return to return to the menu.

Selection (5) LIST THREAD DATA gives a listing of the parameters currently in the program memory.

Selection (6) SAVE THREAD DATA will write thread analysis parameters currently in program memory to a separate file external to the program. User is prompted for a file name, which must be used to recall the saved data when using selection (2).

Selection (7) STATIC AND FATIGUE ANALYSIS solves static and fatigue

TABLE 4.1 THREAD STRESS ANALYSIS INFORMATION INPUT FORM

1. WAIVER NO.: RIW	2. SCN #:	3. PART NO.:
4. ANALYSIS: (1) STATIC OR (2) STAIIC & FATIGUE		5. DATE MACH. (DDMMYY):
6. SUBCODE:	7. BASIC MAJOR DIA. (OR DATUM DIA. FOR PF20) (IN):	
PITCH (PF20): 8. THREADS/IN:	9. THREAD CLASS:	11. HOLLOW DIA. (IN):
10. THREAD FORM: (1) V-THREAD (UN, UNC, UNF OR UNEF)		12. EQUIV O.D. (IN):
(2) ACME THREAD		13. ENGAGEMENT LENGTH (IN):
(3) STUB ACME THREAD		14. INTERRUPTED THRD FACTOR:
(4) BUTTRESS THREAD		15. LOAD FACTOR (1 - 4, 1.5 NOM.):
(5) PF20 THREAD (20/45 BUTT.)		16. T.S. EXT. MEMBER (KSI):
FOR NON-STD DESIGN: PF ANGLE (DEG):		17. T.S. INT. MEMBER (KSI):
CF ANGLE (DEG):		18. Y.S. EXT. MEMBER (KSI):
EXT. ROOT RADIUS (IN):		19. Y.S. INT. MEMBER (KSI):
INT. ROOT RADIUS (IN):		20. THRD SURFACE FINISH EXT.:
ENTER DEVIATED DIM. IN 22-27: (0 IF PER SPEC)		21. THRD SURFACE FINISH INT.:
22. EXT. MAJ. DIA. (IN):	23. EXT. P.D. (DATUM DIA. FOR PF20) (IN):	
24. EXT. MIN. DIA. (IN):	26. INT. P.D. (DATUM DIA. FOR PF20) (IN):	
25. INT. MAJ. DIA. (IN):	27. INT. MIN. DIA. (IN):	
28. PRELOAD: (1) NONE (2) FULL (3) PARTIAL:		(4) BY AXIAL PRELOAD (KIP):
		FRICTION FACTOR:
29. AXIAL LOAD (KIP): MAX.		MIN.
30. INTERNAL PRESSURE (KSI):		31. TEMPERATURE (F DEG) (0 IF UNDER 160):
32. RELIABILITY (R=.5 MEAN): 0.5, 0.9, 0.95, 0.99, 0.999		
REMARK:		

TABLE 4.2 EXAMPLE FOR THREAD STRESS ANALYSIS INFORMATION INPUT FORM

1. WAIVER NO.: RIW 7592	2. SCN #: 3538	3. PART NO.:12007723 (REAR YOKE, INT.THREAD)
4. ANALYSIS: (1) STATIC OR X (2) STATIC & FATIGUE		5. DATE MACH.(DDMMMYY): 14JUN84
6. SUBCODE:	7. BASIC MAJOR DIA.(OR DATUM DIA. FOR PF20)(IN): 7.0625	
8. PITCH (PF20): THREADS/IN: 6	9. THREAD CLASS: 2	11. HOLLOW DIA.(IN): 0
10. THREAD FORM:(1) V-THREAD (UN,UNC,UNF OR UNEF)		12. EQUIV O.D.(IN): 8.3
(2) ACME THREAD		13. ENGAGEMENT LENGTH (IN): 3.185
(3) STUB ACME THREAD		14. INTERRUPTED THRD FACTOR: 0.483
X (4) BUTTRESS THREAD		15. LOAD FACTOR (1-4, 1.5 NOM.): 1.5
(5) PF20 THREAD (20/45 BUTT.)		16. T.S. EXT. MEMBER (KSI): 154
FOR NON-STD DESIGN: PF ANGLE (DEG):		17. T.S. INT. MEMBER (KSI): 130
CF ANGLE (DEG):		18. Y.S. EXT. MEMBER (KSI): 120
EXT. ROOT RADIUS (IN):		19. Y.S. INT. MEMBER (KSI): 95
INT. ROOT RADIUS (IN):		20. THRD SURFACE FINISH EXT.:MACH.& GROUND
ENTER DEVIATED DIM. IN 22-27:(0 IF PER SPEC)		21. THRD SURFACE FINISH INT.:MACH.& GROUND
22. EXT. MAJ. DIA.(IN): 0	23. EXT. P.D. (DATUM DIA.FOR PF20)(IN): 0	
24. EXT. MIN. DIA.(IN): 0	26. INT. P.D. (DATUM DIA.FOR PF20)(IN): 6.7894	
25. INT. MAJ. DIA.(IN): 0	27. INT. MIN. DIA.(IN): 6.9185	
28. PRELOAD: X (1)NONE (2)FULL (3)PARTIAL:	(4)BY AXIAL PRELOAD(KIP):	
(5)BY TORQUE(FT-LB):	FRICTION FACTOR:	
29. AXIAL LOAD(KIP): MAX. 12.20	MIN. 0	
30. INTERNAL PRESSURE(KSI): 0	31. TEMPERATURE(F DEG)(0 IF UNDER 160): 200	
32. RELIABILITY(R=.5 MEAN): X 0.5, 0.9, 0.95, 0.99, 0.999		
REMARK:		

(simple load history) problems under assumption of elasticity for thread parameters currently in program memory. In static analysis, load capacity of the threaded joint and safety factors are calculated under maximum, minimum and actual material conditions corresponding to yield stress and tensile strength. In fatigue analysis, safety factors corresponding to various fatigue life cycle ranges are estimated based on user supplied parameters.

Selection (8) EXIT TO PRIMOS returns user to the PRIME operating system at the conclusion of the thread analysis session.

Specific example sessions for V, Acme, Stub Acme, Buttress, and PF20 Watervliet Special Threads are given in appendices A.5 through A.9, respectively.

The interactive thread analysis program documented in this report is written in PRIME F77, an extended version of FORTRAN 77 which conforms fully to ANSIx3.9-1978. A complete software reference including program variable list, common block definitions, source code listing, and compile load instructions is provided in appendices A.1 through A.4.

5. Discussion

The object of this report is to establish a program for estimating load capacities and fatigue life cycles of designed threaded connection subjected to a simple cyclic loading. Elastic material property is assumed in this report. For a more realistic material model and numerical method of analysis, finite element analysis with assumption of elastic-plastic material model is recommended for this project in the future. This approach has been explored by many researches such as O'Hara (22), and Chen and O'Hara (23).

A parabolic load distribution on pressure flank is proposed in this report to reflect stress response in the threaded connection. Flank angle deviation is assumed to be negligible in the program. If flank angle deviation is significant for a non-conforming thread, bias load distribution may occur and a complicated load distribution program will be needed to describe the mismatched flank angles of non-conforming threaded connection. Hoop stress of internal thread member is considered far less than fillet stresses due to bending and axial loading and is not included in the program. However for external thread member, hoop stress is calculated if internal pressure applied. It is noticed that stress due to shear is far less than triaxial root stresses so that thread failure usually due to fillet stress. Shear failure takes place when threads have significant truncation and reduce thread contact surface.

In fatigue analysis, load history is calculated by using user supplied

axial maximum applied and minimum applied load to calculated alternating and mean stresses. Internal pressure applied to threaded joint is assumed to be in phase with load history. The threaded connection is assumed to be subjected to axial loading, hence, size effect is Cd=1 and load type effect is Cl=0.9. In the program, an experimental fatigue strength diagram for alloy steel with tensile strength Su=125 to 180 ksi under axial loading is adopted. To estimate safety factors at various fatigue life cycles, factors of size effect (Cd), surface finish effect (Cs), load type effect (Cl), modifying factor due to fatigue stress concentration (Ck), temperature effect (Ct) and reliability factor (Cr) are applied. Those factors are adopted from various sources, although precision is not claimed, but the results can serve as a reference or indicator. For material with tensile strength Su less than 125 ksi or larger than 180 ksi, S-N curves with equation (3.9.10) and Goodman lines with equation (3.9.22) can be applied to find fatigue life cycle and safety factor at various fatigue life cycles.

Currently, this program only cover thread forms of UN, UNC, UNF, UNEF, ACME, Stub ACME, Buttress and PF20 Watervliet special thread. It is planned to add additional thread forms used on the components manufactured at Rock Island Arsenal.

6. References

1. FED-STD-H28, Screw-thread standards for federal services, General service Administration, 1978.
2. ANSI B1, American National Standard, ASME, 1973.
3. Smith C.W.,"Effect of fit and truncation on the strength of Whitworth threads",Engineer,July 22,1949.
4. Field J.E., Engineer, #200 and #301, 1955.
5. Sopwith D.G.,"The distribution of load in screw threads" Proceeding Institute of Mechanical Engineering, pp.373-383, 1948.
6. Goodier J.N.,"The distribution of load in the threads of screws" Trans. A.S.M.E.,vol.62, pp.A-10, 1940.
7. Hetenyi M.,"A photoelastic study of bolt and nut fastenings" Trans. A.S.M.E.,vol.65, pp.A-93, 1943.
8. Chalupnik J.D.,"Stress concentrations in bolt-thread roots" Experimental Mechanics, 1967.
9. Cazaud R.,"Fatigue of metals", Chapman and Hall,London,1953.
10. Marino R.l. and Riley W.F.,"Optimizing thread-root countours using photoelastic methods",Experimental Mechanics,Jan.1964.
11. Weigle R.E. and Lasselle R.R.,"Experimental techniques for predicting fatigue failure of cannon-breech mechanisms" February 1965.
12. Neuber H. and Springer J.,Kerbspannungslehre,Berlin 1937 & 1958, trans. by Navy Dept.,David Taylor Model Basin,Washington,Nov.1945.

13. Heywood R.B.,"Designing against fatigue of metals",Reinhold Publishing Corp., New York 1962.

14. Juvinall R.C.,"Stress strain and strength",McGraw-Hill Inc.,1967.

15. Shigley J.E.,"Mechanical engineering design",McGraw-Hill Inc.,1977.

16. Blake J.C. and Kurtz H.J.,"The uncertainties of measuring fastener preload",Machine Design,vol.37, pp.128-131, Sept. 30, 1965.

17. Lewis W.,Proc. Eng. Club, Philadelphia,vol.10, p.16, 1893.

18. Heywood R.B.,"Tensile fillet stresses in loaded projections" Proc. IME, pp.384-391, 1948.

19. Kelley B.W. and Pedersen R.,"The beam strength of modern gear tooth-design",Trans. SAE, vol.66, pp.137-157, 1958.

20. O'Hara G.P.,"Stress concentration in screw threads", ARRADCOM Technical Report, ARLCB-TR-80010, 1980.

21. Peterson R.E.,"Fatigue of metals in engineering and design" ASTM, Philadelphia, 1962.

22. O'hara G.P.,"Elastic-plastic analysis of screw threads", AMCMS Technical Report, ARLCB-TR-80043, November 1980

23. Chen P.C.T. and O'Hara G.P.,"Finite element results of pressurized thick tubes based on two elastic-plastic material models", AMCMS Technical Report, ARLCB-TR-83047, December 1983

APPENDICES

A.1 Program Variable List

PI	=	3.14159 (PHI)
BMJDIA	=	BASIC MAJOR DIAMETER (OR DATUM DIAMETER FOR PF20 THREAD)
EJX	=	MAX MAJOR DIAMETER (EXTERNAL THREAD)
EJN	=	MIN MAJOR DIAMETER (EXTERNAL THREAD)
EJA	=	ACT MAJOR DIAMETER (EXTERNAL THREAD)
EPX	=	MAX PITCH DIAMETER (EXTERNAL THREAD)
EPN	=	MIN PITCH DIAMETER (EXTERNAL THREAD)
EPA	=	ACT PITCH DIAMETER (EXTERNAL THREAD)
EMX	=	MAX MINOR DIAMETER (EXTERNAL THREAD)
EMN	=	MIN MINOR DIAMETER (EXTERNAL THREAD)
EMA	=	ACT MINOR DIAMETER (EXTERNAL THREAD)
IJX	=	MAX MAJOR DIAMETER (INTERNAL THREAD)
IJN	=	MIN MAJOR DIAMETER (INTERNAL THREAD)
IJA	=	ACT MAJOR DIAMETER (INTERNAL THREAD)
IPX	=	MAX PITCH DIAMETER (INTERNAL THREAD)
IPN	=	MIN PITCH DIAMETER (INTERNAL THREAD)
IPA	=	ACT PITCH DIAMETER (INTERNAL THREAD)
IMX	=	MAX MINOR DIAMETER (INTERNAL THREAD)
IMN	=	MIN MINOR DIAMETER (INTERNAL THREAD)
IMA	=	ACT MINOR DIAMETER (INTERNAL THREAD)
A(1)	=	PITCH DIAMETER TOLERANCE (EXT THREAD)
A(2)	=	PITCH DIAMETER TOLERANCE (INT THREAD)
G	=	PITCH ALLOWANCE
T(1)	=	MINIMUM DIAMETER TOLERANCE
T(2)	=	MAXIMUM DIAMETER TOLERANCE
ETS	=	EXTERNAL MEMBER TENSILE STRENGTH
ITS	=	INTERNAL MEMBER TENSILE STRENGTH
EYS	=	EXTERNAL MEMBER YIELD STRENGTH
IYS	=	INTERNAL MEMBER YIELD STRENGTH
TS	=	MINIMUM ULT STRESS BETWEEN EXT & INT ULT STRENGTHS
YS	=	MINIMUM YIELD STRESS BETWEEN EXTERNAL & INTERNAL YIELDS STRENGTHS
ASHEAR	=	SHEAR AREA
SSTRESS	=	SHEAR STRESS DUE TO MAX LOAD
KAEX	=	AXIAL STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)
KAEN	=	AXIAL STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)
KAEA	=	AXIAL STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)
KAIX	=	AXIAL STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)
KAIN	=	AXIAL STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)
KAIA	=	AXIAL STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)
KQEX	=	FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)
KQEN	=	FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)
KQEA	=	FATIGUE STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)
KQIX	=	FATIGUE STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)

KQIN	=	FATIGUE STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)
KQIA	=	FATIGUE STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)
KPEX	=	FINITE LIFE S.C. FACTOR EXT THRD (MAX MATL COND)
KPEN	=	FINITE LIFE S.C. FACTOR EXT THRD (MIN MATL COND)
KPEA	=	FINITE LIFE S.C. FACTOR EXT THRD (ACT MATL COND)
KPIX	=	FINITE LIFE S.C. FACTOR INT THRD (MAX MATL COND)
KPIN	=	FINITE LIFE S.C. FACTOR INT THRD (MIN MATL COND)
KPIA	=	FINITE LIFE S.C. FACTOR INT THRD (ACT MATL COND)
STEX	=	AXIAL STRESS EXT THRD (MAX MATL COND)
STEN	=	AXIAL STRESS EXT THRD (MIN MATL COND)
STEA	=	AXIAL STRESS EXT THRD (ACT MATL COND)
STIX	=	AXIAL STRESS INT THRD (MAX MATL COND)
STIN	=	AXIAL STRESS INT THRD (MIN MATL COND)
STIA	=	AXIAL STRESS INT THRD (ACT MATL COND)
HDIA	=	HOLLOW DIAMETER IN EXTERNAL MEMBER
ODIA	=	EQUIVALENT O.D. OF INTERNAL MEMBER
HV	=	HEIGHT OF SHARP V-THREAD
N	=	NUMBER OF THREADS PER INCH
PITCH	=	PITCH (INVERSE OF THREADS PER INCH)
PFANG	=	PRESSURE FLANK ANGLE (DEGREES)
STD(1)	=	STANDARD OR NON-STANDARD STRING FOR PFANG
CLANG	=	CLEARANCE FLANK ANGLE (DEGREES)
STD(2)		STANDARD OR NON-STANDARD STRING FOR CLANG
PFRAD	=	PRESSURE FLANK ANGLE (RADIANS)
CLRAD	=	CLEARANCE FLANK ANGLE (RADIANS)
ERR	=	MIN ROOT RADIUS (EXT THRD)
STD(3)	=	STANDARD OR NON-STANDARD STRING FOR ERR
IRR	=	MIN ROOT RADIUS (INT THRD)
STD(4)	=	STANDARD OR NON-STANDARD STRING FOR IRR
CLASS	=	THREAD CLASS DESIGNATION
HE1	=	HEIGHT OF THRD IN EXT THRD
HI1	=	HEIGHT OF THRD IN INT THRD
HE2	=	BASIC THREAD HEIGHT EXT THRD
HI2	=	BASIC THREAD HEIGHT INT THRD
LE	=	MINIMUM LENGTH OF ENGAGEMENT (IN)
SERIES	=	THREAD SERIES DESIGNATION
SECTOR	=	DECIMAL FRACTION OF THREAD PORTION LEFT AFTER SEGMENTING
INTFLG	=	FLAG - INDICATES INTERFERENCE CONDITION IF = 1
PRES(1)	=	INTERNAL PRESSURE (PSI)
SHEX	=	HOOP STRESS EXT THRD (MAX MATL COND)
SHEN	=	HOOP STRESS EXT THRD (MIN MATL COND)
SHEA	=	HOOP STRESS EXT THRD (ACT MATL COND)
BLPFS	=	BACKLASH ON PRESSURE FLANK SIDE (TO SPEC COND)
BLCFS	=	BACKLASH ON CLEARANCE FLANK SIDE (TO SPEC COND)
BLPFD	=	BACKLASH ON PRESSURE FLANK SIDE (ACTUAL COND)

BLCFD	=	BACKLASH ON CLEARANCE FLANK SIDE (ACTUAL COND)
BLS	=	BACKLASH TOTAL (TO SPEC COND)
BLD	=	BACKLASH TOTAL (ACTUAL COND)
HELIXS	=	LENGTH OF HELIX
SARA	=	SURFACE CONTACT AREA (TO SPEC COND)
SARAX	=	SURFACE CONTACT AREA (MAX MATL COND)
SARAN	=	SURFACE CONTACT AREA (MIN MATL COND)
SARV	=	% VARIANCE OF SURFACE CONTACT AREA
EJV	=	VARIANCE IN MAJOR DIAMETERS (EXT THRD)
EPV	=	VARIANCE IN PITCH DIAMETERS (EXT THRD)
EMV	=	VARIANCE IN MINOR DIAMETERS (EXT THRD)
IJV	=	VARIANCE IN MAJOR DIAMETERS (INT THRD)
IPV	=	VARIANCE IN PITCH DIAMETERS (INT THRD)
IMV	=	VARIANCE IN MINOR DIAMETERS (INT THRD)
AT	=	STRESS AREA
PREMAX	=	MAXIMUM RECOMMENDED PRELOAD (W/O PLASTIC DEFORMATION)
TORQMAX	=	MAXIMUM RECOMMENDED TORQUE (W/O PLASTIC DEFORMATION)
FPFRAC	=	DECIMAL FRACTION OF MAX ALLOWABLE PRELOAD
LOAD(1)	=	PRELOAD APPLIED TO THREAD JOINT, INPUT AS A DIRECT CLAMPING LOAD, AS A RESULT FROM TIGHTENING TORQUE, OR AS A FRACTION OF MAX ALLOWABLE PRELOAD FORCE AS LIMITED BY THE PLASTIC DEFORMATION OF THE MEMBERS.
LOAD(2)	=	MAX APPLIED FORCE (KIP)
LOAD(3)	=	MIN APPLIED FORCE (KIP)
TORQ	=	APPLIED TORQUE TO THREAD JOINT (FT-LBS)
FF	=	FRICTION FACTOR FOR TIGHTENING TORQUE
TPE	=	TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD (EXT THRD)
TPI	=	TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD (INT THRD)
SEMAX	=	MAX ROOT TRUNCATION FOR EXT THREADS
SEMIN	=	MIN ROOT TRUNCATION FOR EXT THREADS
SIMAX	=	MAX ROOT TRUNCATION FOR INT THREADS
SIMIN	=	MIN ROOT TRUNCATION FOR INT THREADS
EEX	=	HEYWOOD E PARAMETER FOR EXT THREAD (MAX MATL COND)
EEN	=	HEYWOOD E PARAMETER FOR EXT THREAD (MIN MATL COND)
EEA	=	HEYWOOD E PARAMETER FOR EXT THREAD (ACT MATL COND)
EIX	=	HEYWOOD E PARAMETER FOR INT THREAD (MAX MATL COND)
EIN	=	HEYWOOD E PARAMETER FOR INT THREAD (MIN MATL COND)
EIA	=	HEYWOOD E PARAMETER FOR INT THREAD (ACT MATL COND)
M1EX	=	M1 PARAMETER EXT THREAD (MAX MATL COND)
M1EN	=	M1 PARAMETER EXT THREAD (MIN MATL COND)
M1EA	=	M1 PARAMETER EXT THREAD (ACT MATL COND)
M1IX	=	M1 PARAMETER INT THREAD (MAX MATL COND)
M1IN	=	M1 PARAMETER INT THREAD (MIN MATL COND)
M1IA	=	M1 PARAMETER INT THREAD (ACT MATL COND)
ETHETAX	=	ANGLE THETA EXT THREAD (MAX MATL COND)

ETHETAN	=	ANGLE THETA EXT THREAD (MIN MATL COND)
ETHETAA	=	ANGLE THETA EXT THREAD (ACT MATL COND)
ITHETAX	=	ANGLE THETA INT THREAD (MAX MATL COND)
ITHETAN	=	ANGLE THETA INT THREAD (MIN MATL COND)
ITHETAA	=	ANGLE THETA INT THREAD (ACT MATL COND)
DPEX(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (MAX MATL COND)
DPEN(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (MIN MATL COND)
DPEA(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE EXT THRD (ACT MATL COND)
DPIX(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (MAX MATL COND)
DPIN(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (MIN MATL COND)
DPIA(I)	=	DISTANCE FROM ROOT TO CENTER LOAD LINE INT THRD (ACT MATL COND)
		(I) DENOTES INCREMENTALIZED PARABOLIC LOAD DISTRIBUTION (1-7)
BEX(I)	=	HEYWOOD B PARAMETER EXT THRD (MAX MATL COND)
BEN(I)	=	HEYWOOD B PARAMETER EXT THRD (MIN MATL COND)
BEA(I)	=	HEYWOOD B PARAMETER EXT THRD (ACT MATL COND)
BIX(I)	=	HEYWOOD B PARAMETER INT THRD (MAX MATL COND)
BIN(I)	=	HEYWOOD B PARAMETER INT THRD (MIN MATL COND)
BIA(I)	=	HEYWOOD B PARAMETER INT THRD (ACT MATL COND)
AEX(I)	=	HEYWOOD A PARAMETER EXT THRD (MAX MATL COND)
AEN(I)	=	HEYWOOD A PARAMETER EXT THRD (MIN MATL COND)
AEA(I)	=	HEYWOOD A PARAMETER EXT THRD (ACT MATL COND)
AIX(I)	=	HEYWOOD A PARAMETER INT THRD (MAX MATL COND)
AIN(I)	=	HEYWOOD A PARAMETER INT THRD (MIN MATL COND)
AIA(I)	=	HEYWOOD A PARAMETER INT THRD (ACT MATL COND)
KBEX	=	FILLET STRESS CONCENTRATION FACTOR EXT THRD (MAX MATL COND)
KBEN	=	FILLET STRESS CONCENTRATION FACTOR EXT THRD (MIN MATL COND)
KBEA	=	FILLET STRESS CONCENTRATION FACTOR EXT THRD (ACT MATL COND)
KBIX	=	FILLET STRESS CONCENTRATION FACTOR INT THRD (MAX MATL COND)
KBIN	=	FILLET STRESS CONCENTRATION FACTOR INT THRD (MIN MATL COND)
KBIA	=	FILLET STRESS CONCENTRATION FACTOR INT THRD (ACT MATL COND)
PTX(I)	=	THREAD PROJECTION THICKNESS (MAX MATL COND)
PTN(I)	=	THREAD PROJECTION THICKNESS (MIN MATL COND)
PTA(I)	=	THREAD PROJECTION THICKNESS (ACT MATL COND)
T1X(I)	=	SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(MAX MATL COND)
T1N(I)	=	SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(MIN MATL COND)
T1A(I)	=	SECOND COEFFICIENT TERM IN HEYWOOD EQ (UNIT LOAD)(ACT MATL COND)
T2EX(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)
T2EN(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)
T2EA(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)
T2IX(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)
T2IN(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)
T2IA(I)	=	1ST TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)
T3EX(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)
T3EN(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)
T3EA(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)

T3IX(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)
T3IN(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)
T3IA(I)	=	2ND TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)
T4EX(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MAX MATL COND)
T4EN(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (MIN MATL COND)
T4EA(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ EXT THRD (ACT MATL COND)
T4IX(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MAX MATL COND)
T4IN(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (MIN MATL COND)
T4IA(I)	=	3RD TERM INSIDE BRACKETS IN HEYWOOD EQ INT THRD (ACT MATL COND)
SBEXT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (MAX MATL COND)
SBENT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (MIN MATL COND)
SBEAT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST EXT THRD (ACT MATL COND)
SBIXT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (MAX MATL COND)
SBINT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (MIN MATL COND)
SBIAT	=	SUPERIMPOSED ROOT STRESS TOTAL FROM LOAD DIST INT THRD (ACT MATL COND)
GAMMA	=	AXIAL LOAD FACTOR
SOCTEX	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (MAX MATL COND)
SOCTEN	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (MIN MATL COND)
SOCTEA	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE EXT THRD (ACT MATL COND)
SOCTIX	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (MAX MATL COND)
SOCTIN	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (MIN MATL COND)
SOCTIA	=	HYDROSTATIC TENSION ON OCTAHEDRAL PLANE INT THRD (ACT MATL COND)
TOCTEX	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (MAX MATL COND)
TOCTEN	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (MIN MATL COND)
TOCTEA	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE EXT THRD (ACT MATL COND)
TOCTIX	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (MAX MATL COND)
TOCTIN	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (MIN MATL COND)
TOCTIA	=	SIMPLE SHEAR ON OCTAHEDRAL PLANE INT THRD (ACT MATL COND)
SF1YEX	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MAX MATL COND)
SF1YEN	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MIN MATL COND)
SF1YEA	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (ACT MATL COND)
SF1YIX	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MAX MATL COND)
SF1YIN	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MIN MATL COND)
SF1YIA	=	Y.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (ACT MATL COND)
SF2YEX	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MAX MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2YEN	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MIN MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2YEA	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (ACT MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2YIX	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MAX MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2YIN	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MIN MATL COND) (MAC DISTORTION ENERGY THEORY)
SF2YIA	=	Y.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (ACT MATL COND)

(MAX DISTORTION ENERGY THEORY)

SF1TEX	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MAX MATL COND)
SF1TEN	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (MIN MATL COND)
SF1TEA	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS EXT THRD (ACT MATL COND)
SF1TIX	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MAX MATL COND)
SF1TIN	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (MIN MATL COND)
SF1TIA	=	T.S. STATIC S.F. TRIAX TENSILE FILLET STRESS INT THRD (ACT MATL COND)
SF2TEX	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MAX MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2TEN	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (MIN MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2TEA	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS EXT THRD (ACT MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2TIX	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MAX MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2TIN	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (MIN MATL COND) (MAX DISTORTION ENERGY THEORY)
SF2TIA	=	T.S. STATIC S.F. TRIAX SHEAR FILLET STRESS INT THRD (ACT MATL COND) (MAX DISTORTION ENERGY THEORY)
SFYEX	=	OVERALL STATIC S.F. EXT THRD (MAX MATL COND) BASED ON YS
SFYEN	=	OVERALL STATIC S.F. EXT THRD (MIN MATL COND) BASED ON YS
SFYEA	=	OVERALL STATIC S.F. EXT THRD (ACT MATL COND) BASED ON YS
SFYIX	=	OVERALL STATIC S.F. INT THRD (MAX MATL COND) BASED ON YS
SFYIN	=	OVERALL STATIC S.F. INT THRD (MIN MATL COND) BASED ON YS
SFYIA	=	OVERALL STATIC S.F. INT THRD (ACT MATL COND) BASED ON YS
SFTEX	=	OVERALL STATIC S.F. EXT THRD (MAX MATL COND) BASED ON TS
SFTEN	=	OVERALL STATIC S.F. EXT THRD (MIN MATL COND) BASED ON TS
SFTEA	=	OVERALL STATIC S.F. EXT THRD (ACT MATL COND) BASED ON TS
SFTIX	=	OVERALL STATIC S.F. INT THRD (MAX MATL COND) BASED ON TS
SFTIN	=	OVERALL STATIC S.F. INT THRD (MIN MATL COND) BASED ON TS
SFTIA	=	OVERALL STATIC S.F. INT THRD (ACT MATL COND) BASED ON TS
CL	=	LOAD CONSTANT
CD	=	SIZE EFFECT
FCYCLE	=	LOADING CONDITION FOR FATIGUE EVALUATION
ECF	=	SURFACE FINISH FACTOR (EXT THRD)
ICF	=	SURFACE FINISH FACTOR (INT THRD)
ESURF	=	SURFACE FINISH TEXTURE (EXT THRD)
ESURFS	=	SURFACE FINISH TEXT STRING (EXT THRD)
ISURF	=	SURFACE FINISH TEXTURE (INT THRD)
ISURFS	=	SURFACE FINISH TEXT STRING (INT THRD)
TEMP	=	TEMPERATURE (DEGREE F)
CT	=	TEMPERATURE EFFECT FACTOR
REL	=	RELIABILITY OF STANDARD MATERIAL PROPERTIES
CR	=	RELIABILITY FACTOR
EKF	=	FATIGUE STRESS CONCENTRATION FACTOR (EXTERNAL THRD)

```
IKF        =  FATIGUE STRESS CONCENTRATION FACTOR (INTERNAL THRD)
EQ         =  NOTCH SENSITIVITY (EXTERNAL THRD)
IQ         =  NOTCH SENSITIVITY (INTERNAL THRD)
ECK        =  FATIGUE STRESS CONCENTRATION MOD FACTOR (EXTERNAL THRD)
ICK        =  FATIGUE STRESS CONCENTRATION MOD FACTOR (INTERNAL THRD)
ARR(I,J) =  ARRAY HOLDING NOTCH SENSITIVITY CURVE DATA
EC         =  CURVE NUMBER - NOTCH DATA ARRAY (EXTERNAL THRD)
IC         =  CURVE NUMBER - NOTCH DATA ARRAY (INTERNAL THRD)
ESE        =  MODIFIED ENDURANCE LIMIT (EXTERNAL THRD)
ISE        =  MODIFIED ENDURANCE LIMIT (INTERNAL THRD)
EKT        =  THEORETICAL STRESS CONCENTRATION FACTOR (EXTERNAL THRD)
IKT        =  THEORETICAL STRESS CONCENTRATION FACTOR (INTERNAL THRD)
KTC(N,J) =  THEORETICAL STRESS CONCENTRATION CURVE DATA
APPLD      =  APPLIED LOAD IN KIP TO THREAD JOINT
CAPPLD(14)=  MAX STATIC APPLIED LOAD FOR SAFETY FACTOR OF 1
               1,3,5,7,9,11  RELATIVE TO YIELD STRENGTH
               13  OVERALL  BASED ON YS
               14  OVERALL  BASED ON TS
               2,4,6,8,10,12 RELATIVE TO TENSILE STRENGTH
TLCF       =  THREAD LOAD CONCENTRATION FACTOR, APPLIED ONLY TO
              HEYWOOD'S FORMULA,  TLCF=1.5 Normal    RANGE 1 - 4
EMXOCT     =  MAX OCTAHEDRAL TENSILE STRESS (EXTERNAL THRD)
IMXOCT     =  MAX OCTAHEDRAL TENSILE STRESS (INTERNAL THRD)
ESPX       =  STRESS CAUSED BY PRELOAD, MAX MATL COND (EXT THRD)
ESPN       =  STRESS CAUSED BY PRELOAD, MIN MATL COND (EXT THRD)
ESPA       =  STRESS CAUSED BY PRELOAD, ACT MATL COND (EXT THRD)
ISPX       =  STRESS CAUSED BY PRELOAD, MAX MATL COND (INT THRD)
ISPN       =  STRESS CAUSED BY PRELOAD, MIN MATL COND (INT THRD)
ISPA       =  STRESS CAUSED BY PRELOAD, ACT MATL COND (INT THRD)
S(I,J)     =  STRESS CAUSED BY MAX & MIN APPLIED LOADS
              I=1 MAX MATL COND (EXT THRD)    J=1 MAX LOAD
              I=2 MIN MATL COND (EXT THRD)    J=2 MIN LOAD
              I=3 ACT MATL COND (EXT THRD)
              I=4 MAX MATL COND (INT THRD)
              I=5 MIN MATL COND (INT THRD)
              I=6 ACT MATL COND (INT THRD)
MEAN(I)       MEAN STRESS (SAME I MEANING AS FOR S(I,J) ABOVE)
ALT(I)        ALTERNATING STRESS (I - SAME AS ABOVE)
FSF(I,J) =  FATIGUE LIFE SAFETY FACTOR FOR I CYCLE,
                WHERE I=1:  10**3 CYCLES
                      I=2: 3*10**4   "
                      I=3: 10**4   "
                      I=4: 4*10**4   "
                      I=5: 10**5   "
                      I=6: 10**6   "
```

```
                        I=7: 10**7   "
                      J=MATL CONDITION
                         1 - MAX MATL COND EXT THRD
                         2 - MIN MATL COND EXT THRD
                         3 - ACT MATL COND EXT THRD
                         4 - MAX MATL COND INT THRD
                         5 - MIN MATL COND INT THRD
                         6 - ACT MATL COND INT THRD
                      J= 7 - MIN SAFETY FACTOR OF OVER ALL MATL COND
DATE      =  DATE PART MACHINED (ddmmmyy) INTEGER
WVN       =  WAIVER NUMBER - STRING
SCN       =  SHOP CONTROL NUMBER - STRING
PN        =  PART NUMBER - STRING
SDFLAG    =  FLAG FOR TYPE OF ANALYSIS, STATIC OR STATIC + FATIGUE
SUBCODE   =  10 CHARACTER SECONDARY IDENTIFIER
SERIES    =  SERIES IDENTIFIER - INTEGER
             1 - V-THREAD
             2 - ACME
             3 - STUB ACME
             4 - BUTTRESS
             5 - PF20 BUTTRESS
SERSTR    =  SERIES TYPE (UNC, BUTT, UNF, ETC.)
METHD     =  STRING DEFINING ANALYSIS MODE (Static, or Static+Fatigue)
SFY       =  OVERALL SF BASED ON YS
SFT       =  OVERALL SF BASED ON TS
```

A.2 Common Blocks

```
      *** COMMON BLOCK     CB1.THRD ***

       CHARACTER*10 WVN,SCN,PN,SUBCODE,SERSTR,STD(4),CLASS,DATE
       CHARACTER*20 METHD,ESURFS,ISURFS
       CHARACTER*32 FNAME
       INTEGER*4 SDFLAG,SERIES,ESURF,ISURF,TEMP,FLAGO
       REAL*4 PI,EJX,EJN,EJA,EPX,EPN,EPA,EMX,EMN,EMA,IJX,IJN,IJA,IPX,IPN,
      *IPA,IMX,IMN,IMA,A(2),G,T(2),ETS,ITS,EYS,IYS,YS,TS,EJV,EPV,
      *EMV,IJV,IPV,IMV,LOAD(3),PRES(2),HV,SEMAX,SEMIN,SEACT,SIMAX,SIMIN,
      *SIACT,PITCH,LE,AT,VAR(6),HDIA,ODIA,N,ERR,IRR,PFANG,CLANG,PFRAD,
      *CLRAD,SECTOR,REL,FF,TORQ,FPFRAC,TLCF,BMJDIA
       COMMON /ONE/ SDFLAG,SERIES,ESURF,ISURF,TEMP,FLAGO,PI,EJX,EJN,
      *EJA,EPX,EPN,EPA,EMX,EMN,EMA,IJX,IJN,IJA,IPX,IPN,IPA,IMX,IMN,IMA,A,
      *G,T,ETS,ITS,EYS,IYS,YS,TS,EJV,EPV,EMV,IJV,IPV,IMV,LOAD,
      *PRES,HV,SEMAX,SEMIN,SEACT,SIMAX,SIMIN,SIACT,PITCH,LE,AT,VAR,HDIA,
      *ODIA,N,ERR,IRR,PFANG,CLANG,PFRAD,CLRAD,SECTOR,REL,FF,TORQ,FPFRAC,
      *TLCF,BMJDIA,WVN,SCN,PN,SUBCODE,SERSTR,STD,CLASS,DATE,METHD,ESURFS,
      *ISURFS,FNAME


      *** COMMON BLOCK    CB2.THRD ***

       INTEGER*4 INTFLG,LIFE(6)
       REAL*4 BLS,BLD,SARX,SARN,SARA,SARV,BLV,HELIXS,ASHEAR,SSTRESS,
      *SHEX,SHEN,SHEA,KAEX,KAEN,KAEA,KAIX,KAIN,KAIA,STEX,STEN,STEA,STIX,
      *STIN,STIA,SOCTEX,SOCTEN,SOCTEA,SOCTIX,SOCTIN,SOCTIA,TOCTEX,TOCTEN,
      *TOCTEA,TOCTIX,TOCTIN,TOCTIA,EQ,IQ,YSA(7),FSF(7,7),MEAN(6),ALT(6),
      *APPLD,CAPPLD(14),PREMAX,TORQMAX,HE1,HE2,HI1,HI2
       COMMON /TWO/ INTFLG,LIFE,BLS,BLD,SARX,SARN,SARA,SARV,BLV,HELIXS,
      *ASHEAR,SSTRESS,SHEX,SHEN,SHEA,KAEX,KAEN,KAEA,KAIX,KAIN,KAIA,STEX,
      *STEN,STEA,STIX,STIN,STIA,SOCTEX,SOCTEN,SOCTEA,SOCTIX,SOCTIN,SOCTIA
      *,TOCTEX,TOCTEN,TOCTEA,TOCTIX,TOCTIN,TOCTIA,EQ,IQ,YSA,FSF,MEAN,ALT,
      *APPLD,CAPPLD,PREMAX,TORQMAX,HE1,HE2,HI1,HI2


      *** COMMON BLOCK    CB3.THRD ***

       REAL*4 BLPFS,BLCFS,BLPFD,BLCFD,TPE,TPI,EEX,EEN,EEA,EIX,EIN,EIA,
      *M1EX,M1EN,M1EA,M1IX,M1IN,M1IA,ETHETAX,ETHETAN,ETHETAA,ITHETAX,
      *ITHETAN,ITHETAA,DPEX(7),DPEN(7),DPEA(7),DPIX(7),DPIN(7),DPIA(7),
      *BEX(7),BEN(7),BEA(7),BIX(7),BIN(7),BIA(7),AEX(7),AEN(7),AEA(7),
      *AIX(7),AIN(7),AIA(7),KBEX,KBEN,KBEA,KBIX,KBIN,KBIA,PTX(7),PTN(7),
```

```
*PTA(7),T1X(7),T1N(7),T1A(7),T2EX(7),T2EN(7),T2EA(7),T2IX(7),T2IN(7
*),T2IA(7),T3EX(7),T3EN(7),T3EA(7),T3IX(7),T3IN(7),T3IA(7),T4EX(7),
*T4EN(7),T4EA(7),T4IX(7),T4IN(7),T4IA(7),SBEXT,SBENT,SBEAT,SBIXT,
*SBINT,SBIAT,GAMMA,SF1YEX,SF1YEN,SF1YEA,SF1YIX,SF1YIN,SF1YIA,SF2YEX
*,SF2YEN,SF2YEA,SF2YIX,SF2YIN,SF2YIA,SF1TEX,SF1TEN,SF1TEA,SF1TIX,
*SF1TIN,SF1TIA,SF2TEX,SF2TEN,SF2TEA,SF2TIX,SF2TIN,SF2TIA,SFYEX,SFYE
*N,SFYEA,SFYIX,SFYIN,SFYIA,SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA,
*ESPX,ESPN,ESPA,ISPX,ISPN,ISPA,S(12,2),SFY,SFT,LDYE,LDYI,
*LDTE,LDTI,CR,KFEX(7),KFEN(7),KFEA(7),KFIX(7),KFIN(7),KFIA(7),KPEX,
*KPEN,KPEA,KPIX,KPIN,KPIA,KQEX,KQEN,KQEA,KQIX,KQIN,KQIA,KNEX,KNEN,
*KNEA,KNIX,KNIN,KNIA,CL,CD,ECF,ICF,CT,ESE,ISE,EMXOCT,IMXOCT
 COMMON /THREE/ BLPFS,BLCFS,BLPFD,BLCLD,TPE,TPI,EEX,EEN,EEA,EIX,
*EIN,EIA,M1EX,M1EN,M1EA,M1IX,M1IN,M1IA,ETHETAX,ETHETAN,ETHETAA,
*ITHETAX,ITHETAN,ITHETAA,DPEX,DPEN,DPEA,DPIX,DPIN,DPIA,BEX,BEN,
*BEA,BIX,BIN,BIA,AEX,AEN,AEA,AIX,AIN,AIA,KBEX,KBEN,KBEA,KBIX,
*KBIN,KBIA,PTX,PTN,PTA,T1X,T1N,T1A,T2EX,T2EN,T2EA,T2IX,T2IN,T2IA,
*T3EX,T3EN,T3EA,T3IX,T3IN,T3IA,T4EX,T4EN,T4EA,T4IX,T4IN,T4IA,SBEXT,
*SBENT,SBEAT,SBIXT,SBINT,SBIAT,GAMMA,SF1YEX,SF1YEN,SF1YEA,SF1YIX,
*SF1YIN,SF1YIA,SF2YEX,SF2YEN,SF2YEA,SF2YIX,SF2YIN,SF2YIA,SFYEX,
*SFYEN,SFYEA,SFYIX,SFYIN,SFYIA,SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA,
*ESPX,ESPN,ESPA,ISPX,ISPN,ISPA,S,SFY,SFT,LDYE,LDYI,
*LDTE,LDTI,CR,KFEX,KFEN,KFEA,KFIX,KFIN,KFIA,KPEX,KPEN,KPEA,KPIX,
*KPIN,KPIA,KQEX,KQEN,KQEA,KQIX,KQIN,KQIA,KNEX,KNEN,KNEA,KNIX,KNIN,
*KNIA,CL,CD,ECF,ICF,CT,ESE,ISE,EMXOCT,IMXOCT
```

A.3 Compile and Load Instructions

COMPILE INSTRUCTIONS

```
F77 THREAD
F77 H28VEE
F77 H28ACM
F77 H28STB
F77 H28BUT
F77 PF20
F77 INTRO
F77 SAVE
F77 RECALL
F77 INPUT
F77 EDIT
F77 OUTPT
F77 INTCHK
F77 BKLASH
F77 PCVAR
F77 TCLASS
F77 CALCU
F77 RECALC
F77 SURFAR
F77 SAREA
F77 PRELOAD
F77 TORSION
F77 LDHIST
F77 HOOP
F77 SSHEAR
F77 AXSCF
F77 HEYWD
F77 OCT
F77 STATSF
F77 NOTCH
F77 TSCF
F77 FATIGUE
F77 FOUTPT
```

LOAD INSTRUCTIONS

```
SEG -LOAD
 SEG rev 19.2
$ LO THREAD
$ LO H28VEE
$ LO H28ACM
$ LO H28STB
$ LO H28BUT
$ LO PF20
$ LO INTRO
$ LO SAVE
$ LO RECALL
$ LO INPUT
$ LO EDIT
$ LO OUTPT
$ LO INTCHK
$ LO BKLASH
$ LO PCVAR
$ LO TCLASS
$ LO CALCU
$ LO RECALC
$ LO SURFAR
$ LO SAREA
$ LO PRELOD
$ LO TORSION
$ LO LDHIST
$ LO HOOP
$ LO SSHEAR
$ LO AXSCF
$ LO HEYWD
$ LO OCT
$ LO STATSF
$ LO NOTCH
$ LO TSCF
$ LO FATIGUE
$ LO FOUTPT
$ LI VAPPLB
$ LI
LOAD COMPLETE
$ MA 3

$ Q
```

A.4 Main Program and Subroutines

```
C
C ***********************************************************************
C ***                  THREAD PROGRAM CONTROL MODULE                  ***
C ***********************************************************************
C
      PROGRAM THREAD
C
      CHARACTER*3 RETN
      INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      PI=3.14159265359
C
      CALL TNOUA(:115614,INTS(4))
   10 WRITE(1,*) ' '
      WRITE(1,*) '*** THREAD PROGRAM CONTROL MENU ***'
      WRITE(1,*) ' '
      WRITE(1,*) 'INTRODUCTION .................... 1'
      WRITE(1,*) 'RECALL THREAD FILE .............. 2'
      WRITE(1,*) 'INPUT THREAD DATA ............... 3'
      WRITE(1,*) 'EDIT THREAD DATA ................ 4'
      WRITE(1,*) 'LIST THREAD DATA ................ 5'
      WRITE(1,*) 'SAVE THREAD DATA ................ 6'
      WRITE(1,*) 'STATIC AND FATIGUE ANALYSIS ..... 7'
      WRITE(1,*) 'EXIT TO PRIMOS .................. 8'
      WRITE(1,*) ' '
   20 CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=20) PICK
      IF(PICK.LT.1.OR.PICK.GT.8) GOTO 20
      IF(PICK.EQ.1) THEN
        CALL INTRO
        GOTO 10
        ENDIF
      IF(PICK.EQ.2) THEN
        CALL RECALL
        CALL SURFAR
        GOTO 10
        ENDIF
```

```
      IF(PICK.EQ.3) THEN
        CALL INPUT
        GOTO 10
        ENDIF
      IF(PICK.EQ.4) THEN
        CALL EDIT
        GOTO 10
        ENDIF
      IF(PICK.EQ.5) THEN
        CALL OUTPT
       CALL TNOUA('      PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
        READ(1,30) RETN
        IF(RETN.NE.' ') GOTO 40
30      FORMAT(A1)
40      CALL TNOUA(:115514,INTS(4))
        GOTO 10
        ENDIF
      IF(PICK.EQ.6) THEN
        CALL SAVE
        GOTO 10
        ENDIF
      IF(PICK.EQ.7) THEN
        CALL CALCU
        GOTO 10
        ENDIF
      IF(PICK.EQ.8) THEN
        CALL EXIT
        ENDIF
      RETURN
      END
```

```
C
C ************************************************************************
C ***  SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR VEE THREAD FORM  ***
C ************************************************************************
C
C This subroutine generates Unified National thread form geometry for
C v-threads as specified in FED-STD-H28/2 dated 31 March 1978
C
      SUBROUTINE H28VEE
      REAL*4 U0,U1,U2,L1
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      HV=.8660254/N                  /* HEIGHT OF SHARP V-THREAD
      HE1=.708333*HV
      HI1=.66766*HV
      HE2=.625*HV
      HI2=.625*HV
      PITCH=1./N
      L1=BMJDIA                      /* MIN LENGTH OF ENGAGEMENT
      PFANG=30.
      CLANG=30.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      ERR=PITCH/8.
      IRR=PITCH/8.
      IF(SERSTR(1:3).EQ.'UN '.AND.N.GE.12.) L1=9.*PITCH
      IF(SERSTR(1:4).EQ.'UNEF') L1=9.*PITCH
      U0=(.0015*BMJDIA**(1./3.))+.0015*L1**.5+.015*((PITCH)**(2./3.))
      IF(CLASS(1:2).NE.'3 ') THEN
      U1=.3*U0
      ELSE
      U1=0.
      ENDIF
      IF(CLASS(1:2).EQ.'1 ') THEN
        A(1)=1.5*U0
        T(1)=.09*(PITCH**(2./3.))
        A(2)=1.95*U0
        T(2)=HV/6.+A(2)
        ENDIF
      IF(CLASS(1:2).EQ.'2 ') THEN
        A(1)=1.0*U0
        T(1)=.06*(PITCH**(2./3.))
        A(2)=1.3*U0
        T(2)=HV/6.+A(2)
        ENDIF
      IF(CLASS(1:2).EQ.'3 ') THEN
        A(1)=.75*U0
        T(1)=.06*(PITCH**(2./3.))
```

```
        A(2)=.975*U0
        T(2)=HV/6.+A(2)
        ENDIF
      IF(BMJDIA.LT..25.AND.CLASS(1:2).NE.'3 ') THEN
        U2=.05*(PITCH**(2./3.))+.03*PITCH/BMJDIA-.002
        IF(U2.LT..25*PITCH-.4*PITCH**2.) U2=.25*PITCH-.4*PITCH**2.
        IF(U2.GT..394*PITCH) U2=.394*PITCH
        GOTO 10
        ENDIF
      IF(BMJDIA.GE..25.AND.CLASS(1:2).NE.'3 ') THEN
        U2=.25*PITCH-.4*PITCH**2.
        IF(N.LT.4.) U2=.15*PITCH
        GOTO 10
        ENDIF
      U2=.05*(PITCH**(2./3.))+.03*PITCH/BMJDIA-.002
      IF(N.LE.80.AND.N.GE.13.) THEN
        IF(U2.LT..23*PITCH-1.5*PITCH**2.) U2=.23*PITCH-1.5*PITCH**2.
        ENDIF
      IF(N.LE.12.AND.U2.LT..120*PITCH) U2=.120*PITCH
      IF(U2.GT..394*PITCH) U2=.394*PITCH
10    EJX=BMJDIA-U1
      EJN=EJX-T(1)
      EPX=BMJDIA-2.*(.375*HV)-U1
      EPN=EPX-A(1)
      EMX=BMJDIA-2.*(.7083333*HV)-U1
      EMN=EMX
      IJN=EJX+U1
      IJX=IJN+T(2)
      IPN=BMJDIA-2.*(.375*HV)
      IPX=IPN+A(2)
      IMN=BMJDIA-2.*(.625*HV)
      IMX=IMN+U2
      SEMAX=.144338*PITCH
      SEMIN=.0721688*PITCH
      SIMAX=.108253*PITCH
      SIMIN=.0360844*PITCH
      EJX=AINT(EJX*10000.+.5)/10000.
      EJN=AINT(EJN*10000.+.5)/10000.
      EPX=AINT(EPX*10000.+.5)/10000.
      EPN=AINT(EPN*10000.+.5)/10000.
      EMX=AINT(EMX*10000.+.5)/10000.
      EMN=AINT(EMN*10000.+.5)/10000.
      IJX=AINT(IJX*10000.+.5)/10000.
      IJN=AINT(IJN*10000.+.5)/10000.
      IPX=AINT(IPX*10000.+.5)/10000.
      IPN=AINT(IPN*10000.+.5)/10000.
      IMX=AINT(IMX*10000.+.5)/10000.
      IMN=AINT(IMN*10000.+.5)/10000.
      RETURN
      END
```

```
C
C **********************************************************************
C ***  SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR ACME THREADS     ***
C **********************************************************************
C
      SUBROUTINE H28ACM
      REAL*4 STO
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      PITCH=1./N
      PFANG=29./2.
      CLANG=29./2.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      HV=.5*PITCH/TAN(PFRAD)
      IF(CLASS(1:2).EQ.'2G') THEN
        EJX=BMJDIA
        EJN=BMJDIA-.05*PITCH
        IPN=BMJDIA-.5*PITCH
        EPX=IPN-.008*BMJDIA**.5
        EPN=EPX-(.030*PITCH**.5+.006*BMJDIA**.5)
        IF(N.GT.10.) G=.010
        IF(N.LE.10.) G=.020
        EMX=BMJDIA-PITCH-G
        EMN=EMX-1.5*(.030*PITCH**.5+.006*BMJDIA**.5)
        IJN=BMJDIA+G
        IJX=IJN+G
        IPX=IPN+(.030*PITCH**.5+.006*BMJDIA**.5)
        IMB=BMJDIA-PITCH
        IMN=BMJDIA-PITCH
        IMX=IMN+.05*PITCH
        ERR=.06*PITCH
        IRR=.06*PITCH
        SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
        SEMIN=SEMAX-.5*(.03*PITCH**.5+.006*BMJDIA**.5)
        STO=G-(.03*PITCH**.5+.006*BMJDIA**.5)
        IF(STO.GE.0.) THEN
          SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
          SIMIN=SIMAX-STO
          ELSE
          SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
          SIMAX=SIMIN-STO
          ENDIF
        GOTO 50
```

```
  ENDIF
IF(CLASS(1:2).EQ.'3G') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.05*PITCH
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.006*BMJDIA**.5
  EPN=EPX-(.014*PITCH**.5+.0028*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  IJN=BMJDIA+G
  IJX=IJN+G
  IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
  IMB=BMJDIA-PITCH
  IMN=BMJDIA-PITCH
  IMX=IMN+.05*PITCH
  ERR=.06*PITCH
  IRR=.06*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  STO=G-(.0028*BMJDIA**.5+.014*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
    ELSE
    SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
    ENDIF
  GOTO 50
  ENDIF
IF(CLASS(1:2).EQ.'4G') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.05*PITCH
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.004*BMJDIA**.5
  EPN=EPX-(.010*PITCH**.5+.002*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
  IJN=BMJDIA+G
  IJX=IJN+G
  IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
  IMB=BMJDIA-PITCH
```

```
  IMN=BMJDIA-PITCH
  IMX=IMN+.05*PITCH
  ERR=.06*PITCH
  IRR=.06*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.010*PITCH**.5+.0020*BMJDIA**.5)
  STO=G-(.0020*BMJDIA**.5+.010*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
    ELSE
    SIMIN=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
    ENDIF
  GOTO 50
  ENDIF
IF(CLASS(1:2).EQ.'2C') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.0035*BMJDIA**.5
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.008*BMJDIA**.5
  EPN=EPX-(.030*PITCH**.5+.006*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.030*PITCH**.5+.006*BMJDIA**.5)
  IJN=BMJDIA+.001*BMJDIA**.5
  IJX=IJN+.0035*BMJDIA**.5
  IPX=IPN+(.030*PITCH**.5+.006*BMJDIA**.5)
  IMB=BMJDIA-PITCH
  IMN=BMJDIA-PITCH+.1*PITCH
  IMX=IMN+.05*PITCH
  ERR=.07*PITCH
  IRR=.07*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.030*PITCH**.5+.006*BMJDIA**.5)
  STO=.0035*BMJDIA**.5-(.006*BMJDIA**.5+.03*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
    ELSE
    SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
    ENDIF
  GOTO 90
```

```
  ENDIF
IF(CLASS(1:2).EQ.'3C') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.0015*BMJDIA**.5
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.006*BMJDIA**.5
  EPN=EPX-(.014*PITCH**.5+.0028*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  IJN=BMJDIA+.001*BMJDIA**.5
  IJX=IJN+.0035*BMJDIA**.5
  IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
  IMB=BMJDIA-PITCH
  IMN=BMJDIA-PITCH+.1*PITCH
  IMX=IMN+.05*PITCH
  ERR=.07*PITCH
  IRR=.07*PITCH
  SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
  SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
  STO=.0035*BMJDIA**.5-(.0028*BMJDIA**.5+.014*PITCH**.5)
  IF(STO.GE.0.) THEN
    SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMIN=SIMAX-STO
    ELSE
    SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
    SIMAX=SIMIN-STO
    ENDIF
  GOTO 90
  ENDIF
IF(CLASS(1:2).EQ.'4C') THEN
  EJX=BMJDIA
  EJN=BMJDIA-.001*BMJDIA**.5
  IPN=BMJDIA-.5*PITCH
  EPX=IPN-.004*BMJDIA**.5
  EPN=EPX-(.010*PITCH**.5+.002*BMJDIA**.5)
  IF(N.GT.10.) G=.010
  IF(N.LE.10.) G=.020
  EMX=BMJDIA-PITCH-G
  EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
  IJN=BMJDIA-.001*BMJDIA**.5
  IJX=IJN+.002*BMJDIA**.5
  IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
  IMB=BMJDIA-PITCH
```

```
      IMN=BMJDIA-PITCH+.1*PITCH
      IMX=IMN+.05*PITCH
      ERR=.07*PITCH
      IRR=.07*PITCH
      SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
      SEMIN=SEMAX-.5*(.010*PITCH**.5+.002*BMJDIA**.5)
      STO=.002*BMJDIA**.5-(.002*BMJDIA**.5+.01*PITCH**.5)
      IF(STO.GE.0.) THEN
        SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMIN=SIMAX-STO
        ELSE
        SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMAX=SIMIN-STO
        ENDIF
      GOTO 90
      ENDIF
    IF(CLASS(1:2).EQ.'5C') THEN
      EJX=BMJDIA-.025*BMJDIA**.5                 /* B
      EJN=EJX-.0015*BMJDIA**.5
      IPN=EJX-.5*PITCH
      EPX=IPN-.008*BMJDIA**.5
      EPN=EJX-(.014*PITCH**.5+.0028*BMJDIA**.5)
      IF(N.GT.10.) G=.010
      IF(N.LE.10.) G=.020
      EMX=EJX-PITCH-G
      EMN=EMX-1.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
      IJN=EJX+.001*BMJDIA**.5
      IJX=IJN+.0035*BMJDIA**.5
      IPX=IPN+(.014*PITCH**.5+.0028*BMJDIA**.5)
      IMB=EJX-PITCH
      IMN=EJX-PITCH+.1*PITCH
      IMX=IMN+.05*PITCH
      ERR=.07*PITCH
      IRR=.07*PITCH
      SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
      SEMIN=SEMAX-.5*(.014*PITCH**.5+.0028*BMJDIA**.5)
      STO=.0035*BMJDIA**.5-(.0028*BMJDIA**.5+.014*PITCH**.5)
      IF(STO.GE.0.) THEN
        SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMIN=SIMAX-STO
        ELSE
        SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMAX=SIMIN-STO
      ENDIF
      GOTO 90
```

```
      ENDIF
    IF(CLASS(1:2).EQ.'6C') THEN
      EJX=BMJDIA-.025*BMJDIA**.5
      EJN=EJX-.0010*BMJDIA**.5
      IPN=EJX-.5*PITCH
      EPX=IPN-.006*BMJDIA**.5
      EPN=EJX-(.010*PITCH**.5+.002*BMJDIA**.5)
      IF(N.GT.10.) G=.010
      IF(N.LE.10.) G=.020
      EMX=EJX-PITCH-G
      EMN=EMX-1.5*(.010*PITCH**.5+.002*BMJDIA**.5)
      IJN=EJX+.001*BMJDIA**.5
      IJX=IJN+.002*BMJDIA**.5
      IPX=IPN+(.010*PITCH**.5+.002*BMJDIA**.5)
      IMB=EJX-PITCH
      IMN=EJX-PITCH+.1*PITCH
      IMX=IMN+.05*PITCH
      ERR=.07*PITCH
      IRR=.07*PITCH
      SEMAX=(.3707*PITCH-.259*G)/TAN(PFRAD)*.5
      SEMIN=SEMAX-.5*(.01*PITCH**.5+.002*BMJDIA**.5)
      STO=.002*BMJDIA**.5-(.002*BMJDIA**.5+.010*PITCH**.5)
      IF(STO.GE.0.) THEN
        SIMAX=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMIN=SIMAX-STO
        ELSE
        SIMIN=(.3707*PITCH-.259*.001*BMJDIA**.5)/TAN(PFRAD)*.5
        SIMAX=SIMIN-STO
        ENDIF
      GOTO 90
      ENDIF
 50 HE2=.5*PITCH
    HI2=HE2
    HE1=HE2+.5*G
    HI1=HE1
    GOTO 100
 90 HE2=.5*PITCH
    HI2=.45*PITCH
    HE1=HE2+.5*G
    HI1=HI2+.05*PITCH
100 EJX=AINT(EJX*10000.+.5)/10000.
    EJN=AINT(EJN*10000.+.5)/10000.
    EPX=AINT(EPX*10000.+.5)/10000.
    EPN=AINT(EPN*10000.+.5)/10000.
    EMX=AINT(EMX*10000.+.5)/10000.
```

```
EMN=AINT(EMN*10000.+.5)/10000.
IJX=AINT(IJX*10000.+.5)/10000.
IJN=AINT(IJN*10000.+.5)/10000.
IPX=AINT(IPX*10000.+.5)/10000.
IPN=AINT(IPN*10000.+.5)/10000.
IMX=AINT(IMX*10000.+.5)/10000.
IMN=AINT(IMN*10000.+.5)/10000.
RETURN
END
```

```
C
C ***************************************************************************
C ***  SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR STUB ACME THREADS ***
C ***************************************************************************
C
      SUBROUTINE H28STB
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      PITCH=1./N
      IF(CLASS(1:2).EQ.'1 ') HE2=.3*PITCH     /* STD STUB ACME FORM
      IF(CLASS(1:2).EQ.'2 ') HE2=.375*PITCH   /* MODIFIED FORM 1 STUB
      IF(CLASS(1:2).EQ.'3 ') HE2=.25*PITCH    /* MODIFIED FORM 2 STUB
      HI2=HE2
      PFANG=29./2.
      CLANG=29./2.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      ERR=.005*PITCH                /* ASSUME SMALL RADIUS
      IRR=.005*PITCH                /* ASSUME SMALL RADIUS
      HV=.5*PITCH/TAN(PFRAD)
      EJX=BMJDIA                             /* (BASIC)
      EJN=EJX-.05*PITCH
      IPN=EJX-HE2
      EPX=IPN-.008*BMJDIA**.5
      EPN=EPX-(.030*PITCH+.006*BMJDIA**.5)
      IMN=EJX-2.*HE2
      IF(N.GT.10.) G=.010
      IF(N.LE.10.) G=.020
      HE1=HE2+.5*G
      HI1=HE1
      EMX=IMN-G
      EMN=EMX-(.030*PITCH+.006*BMJDIA**.5)
      IJN=EJX+G
      IJX=IJN+(.030*PITCH+.006*BMJDIA**.5)
      IPN=EJX-HE2
      IPX=IPN+(.030*PITCH+.006*BMJDIA**.5)
      IMN=EJX-2.*HE2
      IMX=IMN+.05*PITCH
      SEMAX=(.4224*PITCH-.259*G)/TAN(PFRAD)*.5
      SEMIN=SEMAX
      SIMAX=SEMAX
      SIMIN=SEMAX
      EJX=AINT(EJX*10000.+.5)/10000.
      EJN=AINT(EJN*10000.+.5)/10000.
```

```
EPX=AINT(EPX*10000.+.5)/10000.
EPN=AINT(EPN*10000.+.5)/10000.
EMX=AINT(EMX*10000.+.5)/10000.
EMN=AINT(EMN*10000.+.5)/10000.
IJX=AINT(IJX*10000.+.5)/10000.
IJN=AINT(IJN*10000.+.5)/10000.
IPX=AINT(IPX*10000.+.5)/10000.
IPN=AINT(IPN*10000.+.5)/10000.
IMX=AINT(IMX*10000.+.5)/10000.
IMN=AINT(IMN*10000.+.5)/10000.
RETURN
END
```

```
C
C **********************************************************************
C *** SUBROUTINE TO GENERATE H28 HANDBOOK DATA FOR BUTTRESS FORM ***
C **********************************************************************
C
C  This subroutine generates National Buttress Thread form geometry
C  as specified in FED-STD-H28/14 dated 31 Aug 1978.
C
      SUBROUTINE H28BUT
      REAL*4 A0,C,U(2)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      HE1=.66271/N                      /* HEIGHT OF THRD IN INT & EXT THRD
      HI1=HE1
      HE2=.6/N                          /* BASIC THREAD HEIGHT
      HI2=HE2
      HV=.89064/N                      /* HEIGHT OF SHARP V-THREAD
      PITCH=1./N                       /* INVERSE OF THRD PER IN
      PFANG=7.
      CLANG=45.
      PFRAD=PFANG*PI/180.              /* PRESSURE FACE ANGLE(RAD)
      CLRAD=CLANG*PI/180.              /* CLEARANCE FACE ANGLE(RAD)
      IRR=.0357/N                      /* MIN ROOT RADIUS INT
      ERR=.0357/N                      /* MIN ROOT RADIUS EXT
      IF(CLASS(1:2).EQ.'1 ') C=1.5
      IF(CLASS(1:2).EQ.'2 ') C=1.0
      IF(CLASS(1:2).EQ.'3 ') C=2./3.
      A0=.002*BMJDIA**(1./3.)+.0173*PITCH**.5
      A(1)=C*A0                        /* PITCH DIA TOL (EXT)
      A(2) =A(1)                       /* PITCH DIA TOL (INT)
      G=2. *A0/3.                      /* PITCH ALLOWANCE
      IF(CLASS(1:2).EQ.'1 ') THEN            /* T(1)=T(2) MIN & MAJ DIA TOL
        IF(BMJDIA.LE.1.) T(1)=.005
        IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.) T(1)=.006
        IF(BMJDIA.LE.6..AND.BMJDIA.GT.4.) T(1)=.008
        IF(BMJDIA.LE.10..AND.BMJDIA.GT.6.) T(1)=.01
        IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.011
        IF(BMJDIA.GT.16.) T(1)=.013
        ENDIF
      IF(CLASS(1:2).EQ.'2 ') THEN
        IF(BMJDIA.LE.1.) T(1)=.004
        IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.) T(1)=.005
        IF(BMJDIA.LE.6..AND.BMJDIA.GT.4.) T(1)=.007
        IF(BMJDIA.LE.10..AND.BMJDIA.GT.6.) T(1)=.008
```

```
          IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.009
          IF(BMJDIA.GT.16.) T(1)=.010
          ENDIF
        IF(CLASS(1:2).EQ.'3 ') THEN
          IF(BMJDIA.LE.1.) T(1)=.003
          IF(BMJDIA.LE.1.5.AND.BMJDIA.GT.1.) T(1)=.004
          IF(BMJDIA.LE.4..AND.BMJDIA.GT.1.5) T(1)=.005
          IF(BMJDIA.LE.10..AND.BMJDIA.GT.4.) T(1)=.006
          IF(BMJDIA.LE.16..AND.BMJDIA.GT.10.) T(1)=.007
          IF(BMJDIA.GT.16.) T(1)=.008
          ENDIF
        T(2)=T(1)
        U(2)=T(1)
C       EXTERNAL THREAD DIMENSIONS
        EJX=BMJDIA-G                  /* MAX MAJOR DIA
        EJN=EJX-T(1)                  /* MIN MAJOR DIA
        EPX=EJX-HE2                    /* MAX PITCH DIA
        EPN=EPX-A(1)                  /* MIN PITCH DIA
        EMX=EJX-2.*HE1                 /* MAX MINOR DIA
        EMN=EPX-A(1)-.80803/N         /* MIN MINOR DIA
C       INTERNAL THREAD DIMENSIONS
        BMJDIA=BMJDIA                 /* BASIC MAJOR DIA
        IMN=BMJDIA-2.*HE2              /* MIN MINOR DIA
        IMX=IMN+U(2)                  /* MAX MINOR DIA
        IPN=BMJDIA-HE2                 /* MIN PITCH DIA
        IPX=IPN+A(2)                  /* MAX PITCH DIA
        IJX=IPX+.80803*PITCH               /* MAX MAJOR DIA
        IJN=BMJDIA-2.*HE2+2.*HE1                    /* MIN MAJOR DIA
        SEMAX=.0826*PITCH
        SEMIN=.0413*PITCH
        SIMAX=.0826*PITCH
        SIMIN=.0413*PITCH
        EJX=AINT(EJX*10000.+.5)/10000.
        EJN=AINT(EJN*10000.+.5)/10000.
        EPX=AINT(EPX*10000.+.5)/10000.
        EPN=AINT(EPN*10000.+.5)/10000.
        EMX=AINT(EMX*10000.+.5)/10000.
        EMN=AINT(EMN*10000.+.5)/10000.
        IJX=AINT(IJX*10000.+.5)/10000.
        IJN=AINT(IJN*10000.+.5)/10000.
        IPX=AINT(IPX*10000.+.5)/10000.
        IPN=AINT(IPN*10000.+.5)/10000.
        IMX=AINT(IMX*10000.+.5)/10000.
        IMN=AINT(IMN*10000.+.5)/10000.
        RETURN
        END
```

```
C
C ****************************************************************
C *** SUBROUTINE TO GENERATE PF20 WTV BUTTRESS THREAD FORM ***
C ****************************************************************
C
C This subroutine generates special 20 deg. pressure flank Buttress
C thread form designed by Watervliet Arsenal.
C In this subroutine Datum Dia.=Pitch Dia.=BMJDIA
C
      SUBROUTINE PF20
        INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      PFANG=20.
      CLANG=45.
      PFRAD=PFANG*PI/180.
      CLRAD=CLANG*PI/180.
      WRITE(1,*) 'PITCH=0.250 .................. 1'
      WRITE(1,*) 'PITCH=0.375 .................. 2'
      WRITE(1,*) 'PITCH=0.500 .................. 3'
      WRITE(1,*) 'PITCH=0.750 .................. 4'
    2 CALL TNOUA('SELECT PITCH: ',INTS(14))
      READ(1,'(I2)',ERR=2) PICK
      IF(PICK.LT.1.OR.PICK.GT.4) GOTO 2
      IF(PICK.EQ.1) THEN
        PITCH=0.250
        N=1./PITCH
        HV=0.1833
        SEMAX=.042/(1.+TAN(PFRAD))
        SEMIN=.037/(1.+TAN(PFRAD))
        SIMAX=SEMAX
        SIMIN=SEMIN
        ERR=0.0327
        IRR=0.0327
        EPX=BMJDIA
        EPN=EPX
        EJX=EPX+0.101
        EJN=EJX-0.005
        EMX=EPX-0.139
        EMN=EMX-0.010
        IPX=EPX
        IPN=IPX
        IJN=IPX+0.139
        IJX=IJN+0.010
```

```
  IMN=IPX-0.101
  IMX=IMN+0.005
  GOTO 100
  ENDIF
IF(PICK.EQ.2) THEN
  PITCH=0.375
  N=1./PITCH
  HV=0.2749
  SEMAX=.061/(1.+TAN(PFRAD))
  SEMIN=.056/(1.+TAN(PFRAD))
  SIMAX=SEMAX
  SIMIN=SEMIN
  ERR=0.045
  IRR=0.045
  EPX=BMJDIA
  EPN=EPX
  EJX=EPX+0.151
  EJN=EJX-0.005
  EMX=EPX-0.208
  EMN=EMX-0.010
  IPX=EPX
  IPN=IPX
  IJN=IPX+0.208
  IJX=IJN+0.010
  IMN=IPX-0.151
  IMX=IMN+0.005
  GOTO 100
  ENDIF
IF(PICK.EQ.3) THEN
  PITCH=0.500
  N=1./PITCH
  HV=0.3666
  SEMAX=.079/(1.+TAN(PFRAD))
  SEMIN=.074/(1.+TAN(PFRAD))
  SIMAX=SEMAX
  SIMIN=SEMIN
  ERR=0.061
  IRR=0.061
  EPX=BMJDIA
  EPN=EPX
  EJX=EPX+0.202
  EJN=EJX-0.005
  EMX=EPX-0.278
  EMN=EMX-0.010
  IPX=EPX
```

```
  IPN=IPX
  IJN=IPX+0.278
  IJX=IJN+0.010
  IMN=IPX-0.202
  IMX=IMN+0.005
  GOTO 100
  ENDIF
IF(PICK.EQ.4) THEN
  PITCH=0.75
  N=1./PITCH
  HV=0.5499
  SEMAX=.117/(1.+TAN(PFRAD))
  SEMIN=.112/(1.+TAN(PFRAD))
  SIMAX=SEMAX
  SIMIN=SEMIN
  ERR=0.095
  IRR=0.095
  EPX=BMJDIA
  EPN=EPX
  EJX=EPX+0.302
  EJN=EJX-0.005
  EMX=EPX-0.416
  EMN=EMX-0.010
  IPX=EPX
  IPN=IPX
  IJN=IPX+0.416
  IJX=IJN+0.010
  IMN=IPX-0.302
  IMX=IMN+0.005
  GOTO 100
  ENDIF
100 HE1=EJX-EMN
HI1=HE1
HE2=EJX-IMN
HI2=HE2
RETURN
END
```

```
C
C ************************
C ***   INTRODUCTION   ***
C ************************
C
      SUBROUTINE INTRO
C
      CHARACTER CONT1,CONT2
      EXTERNAL TNOUA
C
      CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      WRITE(1,*) '   This is a thread stress analysis program which solv
     *es static and fatigue'
      WRITE(1,*) '(simple load history) problems under assumption of ela
     *sticity.'
      WRITE(1,*) ' '
      WRITE(1,*) '   Standard thread form data of V thread (UN, UNC,UNF
     *and UNEF), Acme thread,'
      WRITE(1,*) 'stub Acme thread and Buttress thread are generated acc
     *ording to FED-STD-H28 '
      WRITE(1,*) 'screw thread handbook.  Special thread form data of PF
     *20 thread are generated '
      WRITE(1,*) 'per design specification provided by Watervliet Arsena
     *l.'
      WRITE(1,*) ' '
      WRITE(1,*) '   In static analysis, load capacity of threaded joint
     * and safety factors are '
      WRITE(1,*) 'calculated under maximum, minimum and actual material
     *conditions corresponding '
      WRITE(1,*) 'to yield stress and tensile strength.  In fatigue anal
     *ysis, safety factors '
      WRITE(1,*) 'corresponding to various fatigue life cycle ranges are
     * estimated base on user '
      WRITE(1,*) 'supplied input information.'
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      CALL TNOUA('     PRESS RETURN TO CONTINUE',INTS(29))
      READ(1,10) CONT1
      IF(CONT1.NE.' ') GOTO 50
   10 FORMAT(A1)
   50 CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      WRITE(1,*) '   Required input information and examples are listed
     *as follow:'
      WRITE(1,*) '1.  Waiver no.: e.g. RIW1234'
```

```
      WRITE(1,*) '2.  SCN no.: e.g. 1234'
      WRITE(1,*) '3.  Part no.: e.g. 12007723'
      WRITE(1,*) '4.  Analysis methods:(1)static or (2)static & fatigue
     *analysis'
      WRITE(1,*) '5.  Date machined (DDMMMYY): e.g. 05JUL84'
      WRITE(1,*) '6.  Subcode: e.g. 12345 (press return if not applied)'
      WRITE(1,*) '7.  Basic major diameter (or dtaum diameter for PF20 t
     *hread)(in.): e.g. 3.75'
      WRITE(1,*) '8.  Thread/in.: e.g. 6,(or pitch for PF20: e.g. .375)'
      WRITE(1,*) '9.  Thread class: e.g. 2'
      WRITE(1,*) '10. Select thread form from menu & specify non-std  de
     *sign data (if any)'
      WRITE(1,*) '11. Hollow diameter of exterior thread member (in.): e
     *.g. 1.5'
      WRITE(1,*) '12. Equiv. outside diameter of internal thread member
     *(in.): e.g. 10.'
      WRITE(1,*) '13. Thread engagement length (in.): e.g.3.85'
      WRITE(1,*) '14. Interrupted thread factor: e.g. .483, if not secto
     *red enter 1.0'
      WRITE(1,*) '15. Thread load concentration factor (1- 4): e.g. 1.5'
      WRITE(1,*) '16. Tensile strength of external member (ksi): e.g. 16
     *0'
      WRITE(1,*) '17. Tensile strength of internal member (ksi): e.g. 12
     *0'
      WRITE(1,*) '18. Yield stress of external member (ksi): e.g. 130'
      WRITE(1,*) '19. Yield stress of internal member (ksi): e.g. 95'
      WRITE(1,*) '20. Select thread surface finish method for exterior m
     *ember: e.g. machined'
      WRITE(1,*) '21. Select thread surface finish method for internal m
     *ember: e.g. machined'
      WRITE(1,*) '22.-27. Enter deviated dimensions (in.),if no deviatio
     *n enter 0 or press return'
      WRITE(1,*) '28. Select preload condition: none, full, partial,'
      WRITE(1,*) '    by loading (kip) or by torque (ft-lb)'
      WRITE(1,*) '29. Applied load (kip): e.g. max. 200, min. 0'
      WRITE(1,*) '30. Internal pressure (ksi): e.g.    2'
      WRITE(1,*) '31. Temperature (deg F): e.g. 180, enter 0 if less tha
     *n 160'
      WRITE(1,*) '32. Fatigue strength reliability(R): .5, .9, .99, or
     *.999,'
      WRITE(1,*) '    (R=.5 mean fatigue strength, Cr=1)'
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      CALL TNOUA('     PRESS RETURN TO CONTINUE',INTS(29))
      READ(1,10) CONT2
      IF(CONT2.NE.' ') GOTO 100
  100 CALL TNOUA(:115614,INTS(4))
      RETURN
      END
```

```
C
C ***********************************************************************
C ***                      SUBROUTINE TO SAVE DATA                    ***
C ***********************************************************************
C
      SUBROUTINE SAVE
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      CHARACTER*3 YESNO
      INTEGER*2 LEN
      EXTERNAL TNOUA
   10 CALL TNOUA('ENTER FILENAME: ',INTS(16))
      READ(1,'(A32)') FNAME
      LEN=NLEN$A(FNAME,INTS(32))
      IF(FNAME(1:4).EQ.'QUIT'.OR.FNAME(1:4).EQ.'STOP') RETURN
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='NEW',ERR=20)
      GOTO 30
   20 CALL TNOUA('FILE ALREADY EXISTS. DO YOU WANT TO OVERWRITE?: ',IN
     *TS(48))
      READ(1,'(A3)') YESNO
      IF(YESNO(1:1).EQ.'N') GOTO 10
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='OLD',ERR=10)
      REWIND(20)
   30 WRITE(20,40) WVN,SCN,PN,SUBCODE,SERSTR,STD(1),STD(2),STD(3),STD(4)
     *,CLASS,DATE,METHD,ESURFS,ISURFS
   40 FORMAT(11(A10),3(A20))
      WRITE(20,50) SDFLAG,SERIES,ESURF,ISURF,TEMP
   50 FORMAT(4(I1),I4)
      WRITE(20,60) BMJDIA,N,HDIA,ODIA,PFANG,CLANG,LE,ERR,IRR,SECTOR,TLCF
     *,ETS,ITS,EYS,IYS,YS,TS,LOAD(1),LOAD(2),LOAD(3),FPFRAC,TORQ,FF,
     *PRES(1),PRES(2),REL,EJA,EPA,EMA,IJA,IPA,IMA,PITCH
   60 FORMAT(F7.4,F5.2,2(F6.3),3(F5.2),2(F4.3),2(F4.2),6(F6.2),3(F8.2),
     *F4.2,F8.2,F4.2,2(F8.2),F5.4,7(F7.4))
      CLOSE (20)
      RETURN
      END
```

```
C
C ***********************************************************************
C ***                   SUBROUTINE TO RECALL DATA                      ***
C ***********************************************************************
C
      SUBROUTINE RECALL
      CHARACTER*3 YESNO,RET
      INTEGER*2 LEN
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      EXTERNAL TNOUA
   10 CALL TNOUA('ENTER FILENAME: ',INTS(16))
      READ(1,'(A32)') FNAME
      LEN=NLEN$A(FNAME,INTS(32))
      IF(FNAME(1:4).EQ.'QUIT'.OR.FNAME(1:4).EQ.'STOP') RETURN
      OPEN(20,FILE=FNAME(1:INTL(LEN)),STATUS='OLD',ERR=20)
      GOTO 30
   20 WRITE(1,*) 'FILE DOES NOT EXIST.'
      GOTO 10
   30 READ(20,40) WVN,SCN,PN,SUBCODE,SERSTR,STD(1),STD(2),STD(3),STD(4),
     *CLASS,DATE,METHD,ESURFS,ISURFS
   40 FORMAT(11(A10),3(A20))
      READ(20,50) SDFLAG,SERIES,ESURF,ISURF,TEMP
   50 FORMAT(4(I1),I4)
      READ(20,60) BMJDIA,N,HDIA,ODIA,PFANG,CLANG,LE,ERR,IRR,SECTOR,TLCF,
     *ETS,ITS,EYS,IYS,YS,TS,LOAD(1),LOAD(2),LOAD(3),FPFRAC,TORQ,FF,
     *PRES(1),PRES(2),REL,EJA,EPA,EMA,IJA,IPA,IMA,PITCH
   60 FORMAT(F7.4,F5.2,2(F6.3),3(F5.2),2(F4.3),2(F4.2),6(F6.2),3(F8.2),
     *F4.2,F8.2,F4.2,2(F8.2),F5.4,7(F7.4))
      CLOSE (20)
      CALL RECALC
      CALL INTCHK
      CALL SURFAR
      CALL BKLASH
      CALL PCVAR
      CALL OUTPT
      WRITE(1,*) ' '
      CALL TNOUA('      PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
      READ(1,70) RET
      IF(RET.NE.' ') GOTO 100
   70 FORMAT(A1)
  100 CALL TNOUA(:115614,INTS(4))
      RETURN
      END
```

```
C
C ***********************************************************************
C ***              SUBROUTINE FOR THE INPUT MODULE                    ***
C ***********************************************************************
C
      SUBROUTINE INPUT
      CHARACTER*3 YESNO
      INTEGER*4 PICK
      REAL*4 PFANGT,CLANGT,ERRMINT,IRRMINT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      HDIA=0.
      LOAD(1)=0.
      LOAD(2)=100.
      LOAD(3)=0.
      TLCF=1.5
      REL=0.5
      EJA=0.
      EPA=0.
      EMA=0.
      IJA=0.
      IPA=0.
      IMA=0.
      CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) 'THREAD ANALYSIS PROGRAM - DATA INPUT'
      WRITE(1,*) ' '
    3 CALL TNOUA('ENTER WAIVER NO (e.g. RIW1234): ',INTS(32))
      READ(1,'(A7)',ERR=3) WVN
    4 CALL TNOUA('ENTER SHOP CONTROL NUMBER (e.g.123456): ',INTS(40))
      READ(1,'(A6)',ERR=4) SCN
    6 CALL TNOUA('ENTER PART NUMBER (e.g.12007766): ',INTS(34))
      READ(1,'(A10)',ERR=6) PN
    8 CALL TNOUA('ANALYSIS TYPE: (1) STATIC OR (2) STATIC+FATIGUE: ',INT
     *S(49))
      READ(1,'(I1)',ERR=8) SDFLAG
      IF(SDFLAG.GT.2.OR.SDFLAG.LT.1) GOTO 8
      IF(SDFLAG.EQ.1) METHD='Static         '
      IF(SDFLAG.EQ.2) METHD='Static+Fatigue'
    9 CALL TNOUA('ENTER DATE MACHINED (e.g.ddmmmyy): ',INTS(35))
      READ(1,'(A7)',ERR=9) DATE
   10 CALL TNOUA('ENTER SUBCODE: ',INTS(15))
      READ(1,'(A10)',ERR=10) SUBCODE
   12 CALL TNOUA('BASIC MAJOR DIA (OR DATUM DIA FOR PF20): ',INTS(41))
      READ(1,*,ERR=12) BMJDIA
      WRITE(1,*) ' '
      WRITE(1,*)'THREAD FORM TYPE'
      WRITE(1,*) ' '
```

```
      WRITE(1,*) 'V-THREAD .............. 1'
      WRITE(1,*) 'ACME .................. 2'
      WRITE(1,*) 'STUB ACME ............. 3'
      WRITE(1,*) 'BUTTRESS .............. 4'
      WRITE(1,*) 'PF20 .................. 5'
   20 CALL TNOUA('ENTER TYPE: ',INTS(12))
      READ(1,'(I1)',ERR=20) SERIES
      IF(SERIES.LT.1.OR.SERIES.GT.5) GOTO 20
      IF(SERIES.NE.5) THEN
   14   CALL TNOUA('THREADS PER INCH: ',INTS(18))
        READ(1,*,ERR=14) N
        ENDIF
      IF(SERIES.EQ.1) THEN
        WRITE(1,*) ' '
        WRITE(1,*) 'UN .............. 1'
        WRITE(1,*) 'UNC ............. 2'
        WRITE(1,*) 'UNF ............. 3'
        WRITE(1,*) 'UNEF ............ 4'
   22   CALL TNOUA('ENTER: ',INTS(7))
        READ(1,'(I1)',ERR=22) PICK
        IF(PICK.LT.1.OR.PICK.GT.4) GOTO 22
        IF(PICK.EQ.1) SERSTR='UN '
        IF(PICK.EQ.2) SERSTR='UNC'
        IF(PICK.EQ.3) SERSTR='UNF'
        IF(PICK.EQ.4) SERSTR='UNEF'
        CALL TCLASS
        CALL H28VEE
        ENDIF
      IF(SERIES.EQ.2) THEN
        SERSTR='ACME'
        CALL TCLASS
        CALL H28ACM
        ENDIF
      IF(SERIES.EQ.3) THEN
        SERSTR='STUB ACME'
        CALL TCLASS
        CALL H28STB
        ENDIF
      IF(SERIES.EQ.4) THEN
        SERSTR='BUTT'
        CALL TCLASS
        CALL H28BUT
        ENDIF
      IF(SERIES.EQ.5) THEN
        SERSTR='PF20      '
        CLASS='- '
        CALL PF20
        ENDIF
      WRITE(1,*) ' '
      WRITE(1,'(A26,F5.2)') 'PRESSURE FACE (PF ANGLE): ',PFANG
```

```
   WRITE(1,'(A22,F5.2)') 'CLEARANCE (CL ANGLE): ',CLANG
25 CALL TNOUA('STANDARD PF & CL ANGLES?: ',INTS(26))
   STD(1)='        '
   STD(2)='        '
   READ(1,'(A3)',ERR=25) YESNO
   IF(YESNO(1:1).EQ.'N') THEN
26   CALL TNOUA('ENTER PF ANGLE: ',INTS(16))
     READ(1,*,ERR=26) PFANGT
     IF(PFANGT.NE.PFANG) THEN
       STD(1)='non-std'
       PFANG=PFANGT
       ENDIF
28   CALL TNOUA('ENTER CL ANGLE: ',INTS(16))
     READ(1,*,ERR=28) CLANGT
     IF(CLANGT.NE.CLANG) THEN
       STD(2)='non-std'
       CLANG=CLANGT
       ENDIF
     CALL RECALC
     ENDIF
   WRITE(1,*) ' '
   WRITE(1,'(A22,F5.4)') 'EXT THRD ROOT RADIUS: ',ERR
   WRITE(1,'(A22,F5.4)') 'INT THRD ROOT RADIUS: ',IRR
30 CALL TNOUA('STANDARD THREAD ROOT RADII?: ',INTS(29))
   STD(3)='    '
   STD(4)='    '
   READ(1,'(A3)',ERR=30) YESNO
   IF(YESNO(1:1).EQ.'N') THEN
32   CALL TNOUA('ENTER EXT THRD ROOT RADIUS: ',INTS(28))
     READ(1,'(F5.4)',ERR=32) ERRMINT
     IF(ERRMINT.NE.ERR) THEN
       STD(3)='non-std'
       ERR=ERRMINT
       ENDIF
34   CALL TNOUA('ENTER INT THRD ROOT RADIUS: ',INTS(28))
     READ(1,'(F5.4)',ERR=34) IRRMINT
     IF(IRRMINT.NE.IRR) THEN
       STD(4)='non-std'
       IRR=IRRMINT
       ENDIF
     CALL RECALC
     ENDIF
40 CALL TNOUA('HOLLOW DIA(in): ',INTS(16))
   READ(1,*,ERR=40) HDIA
   IF(HDIA.GE.BMJDIA) THEN
     WRITE(1,*) 'HOLLOW DIA MUST BE LESS THAN EXT MEMBER DIA.'
     GOTO 40
     ENDIF
42 CALL TNOUA('EQUIV O.D.(in): ',INTS(16))
   READ(1,*,ERR=42) ODIA
```

```
      IF(ODIA.LE.BMJDIA) THEN
        WRITE(1,*) 'EQUIV OD MUST BE GREATER THEN INT THRD DIA.'
        GOTO 42
        ENDIF
44    CALL TNOUA('THRD ENGAGEMENT LENGTH: ',INTS(24))
      READ(1,*,ERR=44) LE
46    CALL TNOUA('THRD SEGMENT (FRACTION OF FULL): ',INTS(33))
      READ(1,*,ERR=46) SECTOR
      IF(SECTOR.LT..249) THEN
        WRITE(1,*) 'CURRENT LOWER SEGMENT LIMIT IS .25'
        GOTO 46
        ENDIF
48    CALL TNOUA('LOAD FACTOR(1.5 normal): ',INTS(25))
      READ(1,*,ERR=48) TLCF
50    CALL TNOUA('ULTIMATE STRENGTH (EXT MEMBER) KSI: ',INTS(36))
      READ(1,*,ERR=50) ETS
52    CALL TNOUA('YIELD STRENGTH (EXT MEMBER) KSI: ',INTS(34))
      READ(1,*,ERR=52) EYS
54    CALL TNOUA('ULTIMATE STRENGTH (INT MEMBER) KSI: ',INTS(36))
      READ(1,*,ERR=54) ITS
56    CALL TNOUA('YIELD STRENGTH (INT MEMBER) KSI: ',INTS(34))
      READ(1,*,ERR=56) IYS
      YS=AMIN1(EYS,IYS)
      WRITE(1,*) YS
      TS=AMIN1(ETS,ITS)
      WRITE(1,*) ' '
      WRITE(1,*) '** SURFACE FINISH FOR EXTERNAL MEMBER **'
      WRITE(1,*) ' '
      WRITE(1,*) 'MIRROR POLISHED ...... 1'
      WRITE(1,*) 'FINE GROUND .......... 2'
      WRITE(1,*) 'MACHINED ............. 3'
      WRITE(1,*) 'HOT ROLLED ........... 4'
      WRITE(1,*) 'AS FORGED ............ 5'
      CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=58) ESURF
      IF(ESURF.LT.1.OR.ESURF.GT.5) GOTO 58
      IF(ESURF.EQ.1) ESURFS='MIRROR POLISHED'
      IF(ESURF.EQ.2) ESURFS='FINE GROUND'
      IF(ESURF.EQ.3) ESURFS='MACHINED'
      IF(ESURF.EQ.4) ESURFS='HOT ROLLED'
      IF(ESURF.EQ.5) ESURFS='AS FORGED'
      W[illegible]* ' '
      [illegible] '** SURFACE FINISH [illegible] INTERNAL MEMBER **'
      [illegible] '
      [illegible] MIRROR PO[illegible]HED ...... 1'
      [illegible] ......... 2'
      [illegible] ............. 3'
      W[illegible],* 'H[illegible] ROLLED ........... 4'
      W[illegible],* 'A[illegible] FORGED ............ 5'
      [illegible]'ENTER: ',INTS(7))
```

```
      READ(1,'(I1)',ERR=60) ISURF
      IF(ISURF.LT.1.OR.ISURF.GT.5) GOTO 60
      IF(ISURF.EQ.1) ISURFS='MIRROR POLISHED'
      IF(ISURF.EQ.2) ISURFS='FINE GROUND'
      IF(ISURF.EQ.3) ISURFS='MACHINED'
      IF(ISURF.EQ.4) ISURFS='HOT ROLLED'
      IF(ISURF.EQ.5) ISURFS='AS FORGED'
      WRITE(1,*) '*** EXTERNAL THREAD ***'
   62 CALL TNOUA('MAJOR DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=62) EJA
      WRITE(1,*) '*** EXTERNAL THREAD ***'
   64 CALL TNOUA('PITCH DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=64) EPA
      WRITE(1,*) '*** EXTERNAL THREAD ***'
   66 CALL TNOUA('MINOR DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=66) EMA
      WRITE(1,*) '*** INTERNAL THREAD ***'
   68 CALL TNOUA('MAJOR DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=68) IJA
      WRITE(1,*) '*** INTERNAL THREAD ***'
   70 CALL TNOUA('PITCH DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=70) IPA
      WRITE(1,*) '*** INTERNAL THREAD ***'
   72 CALL TNOUA('MINOR DIA DEVIATION(in): ',INTS(25))
      READ(1,'(F7.4)',ERR=72) IMA
      CALL INTCHK
      CALL SURFAR
      CALL BKLASH
      CALL PCVAR
      CALL PRELOD
   74 CALL TNOUA('ENTER MAX APPLIED AXIAL LOAD(kip): ',INTS(35))
      READ(1,*,ERR=74) LOAD(2)
   76 CALL TNOUA('ENTER MIN APPLIED AXIAL LOAD(kip): ',INTS(35))
      READ(1,*,ERR=76) LOAD(3)
      IF(HDIA.EQ.0.) GOTO 82
   78 CALL TNOUA('ENTER INTERNAL PRESSURE(PSI): ',INTS(30))
      READ(1,*,ERR=78) PRES(1)
   82 CALL TNOUA('ENTER TEMPERATURE(deg F): ',INTS(26))
      READ(1,'(I4)',ERR=82) TEMP
      WRITE(1,*) ' '
      WRITE(1,*) '* FATIGUE DATA RELIABILITY FACTOR *'
      WRITE(1,*) ' '
      WRITE(1,*) '.5 (mean) .......... 1'
      WRITE(1,*) '.9 ................. 2'
      WRITE(1,*) '.95 ................ 3'
      WRITE(1,*) '.99 ................ 4'
   84 CALL TNOUA(' ENTER: ',INTS(8))
      READ(1,'(I1)',ERR=84) IPICK
      IF(IPICK.LT.1.OR.IPICK.GT.4) GOTO 84
      IF(IPICK.EQ.1) REL=.5
```

```
      IF(IPICK.EQ.2) REL=.9
      IF(IPICK.EQ.3) REL=.95
      IF(IPICK.EQ.4) REL=.99
      CALL TNOUA(:115614,INTS(4))
  100 RETURN
      END
```

```
C
C ***********************************************************************
C ***    SUBROUTINE TO EDIT THREAD DATA                               ***
C ***********************************************************************
C
      SUBROUTINE EDIT
      CHARACTER*3 YESNO
      INTEGER*4 PICK
      REAL*4 PFANGT,CLANGT,ERRMINT,IRRMINT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
    5 CALL OUTPT
   10 CALL TNOUA('ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):',INTS(44))
      READ(1,'(I2)',ERR=10) PICK
      IF(PICK.EQ.1) THEN
   12   CALL TNOUA('NEW WAIVER NO: ',INTS(15))
        READ(1,'(A7)',ERR=12) WVN
        GOTO 5
        ENDIF
      IF(PICK.EQ.2) THEN
   14   CALL TNOUA('NEW SHOP CONTROL NO: ',INTS(21))
        READ(1,'(A10)',ERR=14) SCN
        GOTO 5
        ENDIF
      IF(PICK.EQ.3) THEN
   16   CALL TNOUA('NEW PART NO: ',INTS(13))
        READ(1,'(A10)',ERR=16) PN
        GOTO 5
        ENDIF
      IF(PICK.EQ.4) THEN
   18   CALL TNOUA('ANALYSIS TYPE: (1) STATIC OR (2) STATIC+FATIGUE: ',I
     *NTS(49))
        READ(1,'(I2)',ERR=18) SDFLAG
        IF(SDFLAG.LT.1.OR.SDFLAG.GT.2) GOTO 18
        IF(SDFLAG.EQ.1) METHD='Static        '
        IF(SDFLAG.EQ.2) METHD='Static+Fatigue'
        GOTO 5
        ENDIF
      IF(PICK.EQ.5) THEN
   20   CALL TNOUA('NEW DATE MACHINED(ddmmmyy): ',INTS(28))
        READ(1,'(A7)',ERR=20) DATE
        GOTO 5
        ENDIF
```

```
      IF(PICK.EQ.6) THEN
22      CALL TNOUA('NEW SUBCODE: ',INTS(13))
        READ(1,'(A10)',ERR=22) SUBCODE
        GOTO 5
        ENDIF
      IF(PICK.EQ.7) THEN
24      CALL TNOUA('NEW BASIC DIA (or DATUM DIA for PF20)(in): ',[illegible]
     *))
        READ(1,*,ERR=24) BMJDIA
        CALL RECALC
        CALL INTCHK
        CALL SURFAR
        CALL BKLASH
        CALL PCVAR
        CALL PRELOD
        GOTO 5
        ENDIF
      IF(PICK.EQ.8) THEN
        IF(SERSTR.EQ.'PF20') THEN
26        CALL TNOUA('NEW PITCH: ',INTS(11))
          READ(1,*,ERR=26) PITCH
          N=1./PITCH
        ELSE
27        CALL TNOUA('NEW THREADS/IN: ',INTS(16))
          READ(1,*,ERR=27) N
          PITCH=1./N
          ENDIF
        CALL RECALC
        CALL INTCHK
        CALL SURFAR
        CALL BKLASH
        CALL PCVAR
        CALL PRELOD
        GOTO 5
        ENDIF
      IF(PICK.EQ.9) THEN
28      CALL TCLASS
        CALL RECALC
        CALL INTCHK
        CALL SURFAR
        CALL BKLASH
        CALL PCVAR
        CALL PRELOD
        GOTO 5
        ENDIF
```

```
      IF(PICK.EQ.10) THEN
        WRITE(1,*) ' '
        WRITE(1,*) 'THREAD FORM TYPE(SERIES)'
        WRITE(1,*) ' '
        WRITE(1,*) 'V-THREAD .............. 1'
        WRITE(1,*) 'ACME .................. 2'
        WRITE(1,*) 'STUB ACME ............. 3'
        WRITE(1,*) 'BUTTRESS .............. 4'
        WRITE(1,*) 'PF20 .................. 5'
30      CALL TNOUA('ENTER TYPE: ',INTS(12))
        READ(1,'(I1)',ERR=30) SERIES
        IF(SERIES.LT.1.OR.SERIES.GT.5) GOTO 30
        IF(SERIES.EQ.1) THEN
          WRITE(1,*) ' '
          WRITE(1,*) 'UN .............. 1'
          WRITE(1,*) 'UNC ............. 2'
          WRITE(1,*) 'UNF ............. 3'
          WRITE(1,*) 'UNEF ............ 4'
          WRITE(1,*) ' '
32        CALL TNOUA('ENTER: ',INTS(7))
          READ(1,'(I1)',ERR=32) PICK
          IF(PICK.LT.1.OR.PICK.GT.4) GOTO 32
          IF(PICK.EQ.1) SERSTR='UN '
          IF(PICK.EQ.2) SERSTR='UNC'
          IF(PICK.EQ.3) SERSTR='UNF'
          IF(PICK.EQ.4) SERSTR='UNEF'
          CALL TCLASS
          CALL H28VEE
          ENDIF
        IF(SERIES.EQ.2) THEN
          SERSTR='ACME'
          CALL TCLASS
          CALL H28ACM
          ENDIF
        IF(SERIES.EQ.3) THEN
          SERSTR='STUB ACME'
          CALL TCLASS
          CALL H28STB
          ENDIF
        IF(SERIES.EQ.4) THEN
          SERSTR='BUTT'
          CALL TCLASS
          CALL H28BUT
          ENDIF
        IF(SERIES.EQ.5) THEN
```

```
      SERSTR='PF20 '
      CLASS=' -'
      CALL TCLASS
      CALL PF20
      ENDIF
    WRITE(1,*) ' '
34  CALL TNOUA('STANDARD PF & CL ANGLES?: ',INTS(26))
    STD(1)='        '
    STD(2)='        '
    READ(1,'(A3)',ERR=34) YESNO
    IF(YESNO(1:1).EQ.'N') THEN
36    CALL TNOUA('ENTER PF ANGLE: ',INTS(16))
      READ(1,*,ERR=36) PFANGT
      IF(PFANGT.NE.PFANG) THEN
        STD(1)='non-std'
        PFANG=PFANGT
        ENDIF
38    CALL TNOUA('ENTER CL ANGLE: ',INTS(16))
      READ(1,*,ERR=38) CLANGT
      IF(CLANGT.NE.CLANG) THEN
        STD(2)='non-std'
        CLANG=CLANGT
        ENDIF
      ENDIF
    WRITE(1,*) ' '
40  CALL TNOUA('STANDARD THREAD ROOT RADII?: ',INTS(29))
    STD(3)='        '
    STD(4)='        '
    READ(1,'(A3)',ERR=30) YESNO
    IF(YESNO(1:1).EQ.'N') THEN
42    CALL TNOUA('ENTER EXT THRD ROOT RADIUS: ',INTS(28))
      READ(1,'(F5.4)',ERR=42) ERRMINT
      IF(ERRMINT.NE.ERR) THEN
      STD(3)='non-std'
      ERR=ERRMINT
      ENDIF
44    CALL TNOUA('ENTER INT THRD ROOT RADIUS: ',INTS(28))
      READ(1,'(F5.4)',ERR=44) IRRMINT
      IF(IRRMINT.NE.IRR) THEN
        STD(4)='non-std'
        IRR=IRRMINT
        ENDIF
      ENDIF
    CALL RECALC
    CALL INTCHK
```

```
      CALL SURFAR
      CALL BKLASH
      CALL PCVAR
      CALL PRELOD
      GOTO 5
      ENDIF
    IF(PICK.EQ.11) THEN
46    CALL TNOUA('NEW HOLLOW DIA(in): ',INTS(20))
      READ(1,*,ERR=46) HDIA
      IF(HDIA.GE.BMJDIA) THEN
        WRITE(1,*) 'HOLLOW DIA MUST BE LESS THAN EXT MEMBER DIA.'
        GOTO 46
        ENDIF
      GOTO 5
      ENDIF
    IF(PICK.EQ.12) THEN
48    CALL TNOUA('NEW EQUIV O.D.(in): ',INTS(20))
      READ(1,*,ERR=48) ODIA
      IF(ODIA.LE.BMJDIA) THEN
        WRITE(1,*) 'EQUIV OD MUST BE GREATER THAN INT THRD DIA.'
        GOTO 48
        ENDIF
      GOTO 5
      ENDIF
    IF(PICK.EQ.13) THEN
50    CALL TNOUA('NEW ENGAGEMENT LENGTH(in): ',INTS(27))
      READ(1,*,ERR=50) LE
      GOTO 5
      ENDIF
    IF(PICK.EQ.14) THEN
52    CALL TNOUA('NEW THRD SEGMENT (FRACTION OF FULL): ',INTS(36))
      READ(1,*,ERR=52) SECTOR
      IF(SECTOR.LT..249) THEN
        WRITE(1,*) 'CURRENT LOWER LIMIT IS .25'
        GOTO 52
        ENDIF
      IF(SECTOR.GT.1.) GOTO 52
      GOTO 5
      ENDIF
    IF(PICK.EQ.15) THEN
54    CALL TNOUA('NEW LOAD FACTOR(1.5 normal): ',INTS(29))
      READ(1,*,ERR=54) TLCF
      GOTO 5
      ENDIF
    IF(PICK.EQ.16) THEN
```

```
56   CALL TNOUA('NEW T.S. EXT MEMBER(ksi): ',INTS(26))
     READ(1,*,ERR=56) ETS
     TS=AMIN1(ETS,ITS)
     GOTO 5
     ENDIF
   IF(PICK.EQ.17) THEN
58   CALL TNOUA('NEW T.S. INT MEMBER(ksi): ',INTS(26))
     READ(1,*,ERR=58) ITS
     TS=AMIN1(ETS,ITS)
     GOTO 5
     ENDIF
   IF(PICK.EQ.18) THEN
60   CALL TNOUA('NEW Y.S. EXT MEMBER(ksi): ',INTS(26))
     READ(1,*,ERR=60) EYS
     YS=AMIN1(EYS,IYS)
     GOTO 5
     ENDIF
   IF(PICK.EQ.19) THEN
62   CALL TNOUA('NEW Y.S. INT MEMBER(ksi): ',INTS(26))
     READ(1,*,ERR=62) IYS
     YS=AMIN1(EYS,IYS)
     GOTO 5
     ENDIF
   IF(PICK.EQ.20) THEN
     WRITE(1,*) ' '
     WRITE(1,*) '** SURFACE FINISH FOR EXTERNAL MEMBER **'
     WRITE(1,*) ' '
     WRITE(1,*) 'MIRROR POLISHED ...... 1'
     WRITE(1,*) 'FINE GROUND .......... 2'
     WRITE(1,*) 'MACHINED ............. 3'
     WRITE(1,*) 'HOT ROLLED ........... 4'
     WRITE(1,*) 'AS FORGED ............ 5'
64   CALL TNOUA('ENTER: ',INTS(7))
     READ(1,'(I1)',ERR=64) ESURF
     IF(ESURF.LT.1.OR.ESURF.GT.5) GOTO 64
     IF(ESURF.EQ.1) ESURFS='MIRROR POLISHED'
     IF(ESURF.EQ.2) ESURFS='FINE GROUND'
     IF(ESURF.EQ.3) ESURFS='MACHINED'
     IF(ESURF.EQ.4) ESURFS='HOT ROLLED'
     IF(ESURF.EQ.5) ESURFS='AS FORGED'
     GOTO 5
     ENDIF
   IF(PICK.EQ.21) THEN
     WRITE(1,*) ' '
     WRITE(1,*) '** SURFACE FINISH FOR INTERNAL MEMBER **'
```

```
      WRITE(1,*) ' '
      WRITE(1,*) 'MIRROR POLISHED ...... 1'
      WRITE(1,*) 'FINE GROUND .......... 2'
      WRITE(1,*) 'MACHINED ............. 3'
      WRITE(1,*) 'HOT ROLLED ........... 4'
      WRITE(1,*) 'AS FORGED ............ 5'
66    CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=66) ISURF
      IF(ISURF.LT.1.OR.ISURF.GT.5) GOTO 66
      IF(ISURF.EQ.1) ISURFS='MIRROR POLISHED'
      IF(ISURF.EQ.2) ISURFS='FINE GROUND'
      IF(ISURF.EQ.3) ISURFS='MACHINED'
      IF(ISURF.EQ.4) ISURFS='HOT ROLLED'
      IF(ISURF.EQ.5) ISURFS='AS FORGED'
      GOTO 5
      ENDIF
    IF(PICK.EQ.22) THEN
      WRITE(1,*) '*** EXTERNAL THREAD ***'
68    CALL TNOUA('NEW MAJOR DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=68) EJA
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
    IF(PICK.EQ.23) THEN
      WRITE(1,*) '*** EXTERNAL THREAD ***'
70    CALL TNOUA('NEW PITCH DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=70) EPA
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
    IF(PICK.EQ.24) THEN
      WRITE(1,*) '*** EXTERNAL THREAD ***'
72    CALL TNOUA('NEW MINOR DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=72) EMA
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
    IF(PICK.EQ.25) THEN
      WRITE(1,*) '*** INTERNAL THREAD ***'
```

```
74    CALL TNOUA('NEW MAJOR DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=74) IJA
      IF(IJA.LE.IJX.AND.IJA.GE.IJN) IJA=0.
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
     IF(PICK.EQ.26) THEN
      WRITE(1,*) '*** INTERNAL THREAD ***'
76    CALL TNOUA('NEW PITCH DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=76) IPA
      IF(IPA.LE.IPX.AND.IPA.GE.IPN) IPA=0.
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
     IF(PICK.EQ.27) THEN
      WRITE(1,*) '*** INTERNAL THREAD ***'
78    CALL TNOUA('NEW MINOR DIA(in) DEVIATION: ',INTS(29))
      READ(1,'(F7.4)',ERR=78) IMA
      IF(IMA.LE.IMX.AND.IMA.GE.IMN) IMA=0.
      CALL INTCHK
      CALL SURFAR
      CALL PCVAR
      GOTO 5
      ENDIF
     IF(PICK.EQ.28) THEN
      CALL PRELOD
      GOTO 5
      ENDIF
     IF(PICK.EQ.29) THEN
 80   CALL TNOUA('ENTER MAX APPLIED AXIAL LOAD(kip): ',INTS(35))
      READ(1,*,ERR=80) LOAD(2)
 82   CALL TNOUA('ENTER MIN APPLIED AXIAL LOAD(kip): ',INTS(35))
      READ(1,*,ERR=82) LOAD(3)
      GOTO 5
      ENDIF
     IF(PICK.EQ.30) THEN
      IF(HDIA.EQ.0.) THEN
        WRITE(1,*) 'EXT THRD MEMBER IS NOT HOLLOW'
        GOTO 100
        ENDIF
 84   CALL TNOUA('ENTER INTERNAL PRESSURE(KSI): ',INTS(30))
      READ(1,*,ERR=84) PRES(1)
      GOTO 5
      ENDIF
```

```
      IF(PICK.EQ.31) THEN
88      CALL TNOUA('ENTER TEMPERATURE(deg F): ',INTS(26))
        READ(1,'(I4)',ERR=88) TEMP
        GOTO 5
        ENDIF
      IF(PICK.EQ.32) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '* FATIGUE DATA RELIABILITY FACTOR *'
        WRITE(1,*) ' '
        WRITE(1,*) '.5 (mean) .......... 1'
        WRITE(1,*) '.9 ................. 2'
        WRITE(1,*) '.95 ................ 3'
        WRITE(1,*) '.99 ................ 4'
92      CALL TNOUA(' ENTER: ',INTS(8))
        READ(1,'(I1)',ERR=92) IPICK
        IF(IPICK.LT.1.OR.IPICK.GT.4) GOTO 84
        IF(IPICK.EQ.1) REL=.5
        IF(IPICK.EQ.2) REL=.9
        IF(IPICK.EQ.3) REL=.95
        IF(IPICK.EQ.4) REL=.99
        GOTO 5
        ENDIF
100     CALL TNOUA(:115614,INTS(4))
      RETURN
      END
```

```
C
C ****************************************************************************
C ***  SUBROUTINE TO GENERATE INTERMEDIATE OUTPUT FOR REVIEW & EDIT  ***
C ****************************************************************************
C
      SUBROUTINE OUTPT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      REAL*4  EJTOL,EPTOL,EMTOL,IJTOL,IPTOL,IMTOL
      EXTERNAL TNOUA
      CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) '                          *** THREAD DATA ***'
      WRITE(1,*) ' '
      WRITE(1,10) ' 1. WAIVER NO:',WVN,'2. SCN#:',SCN,'3. PART NO:',PN
   10 FORMAT(A14,1X,A7,8X,A8,1X,A7,8X,A11,1X,A8)
      WRITE(1,11) ' 4. METHOD:',METHD,'5. DATE MACH:',DATE,'6. SUBCODE:'
     *,SUBCODE
   11 FORMAT(A11,1X,A14,4X,A13,1X,A7,3X,A11,1X,A10)
      IF(SERIES.EQ.5) THEN
      WRITE(1,12) ' 7. DATUM DIA(in):',BMJDIA,'8. PITCH: ',PITCH
   12 FORMAT(A18,1X,F7.4,4X,A10,1X,F7.4)
      ENDIF
      IF(SERIES.NE.5) THEN
      WRITE(1,13) ' 7. BASIC DIA(in):',BMJDIA,'8. THREADS/IN:',N,'9. CLA
     *SS:',CLASS
   13 FORMAT(A18,1X,F7.4,4X,A14,1X,F5.2,4X,A9,1X,A2)
      ENDIF
      WRITE(1,*) ' '
      WRITE(1,14) '10. THREAD FORM:',SERSTR,'11. HOLLOW DIA(in):',HDIA
   14 FORMAT(A16,1X,A10,17X,A19,1X,F6.3)
      WRITE(1,16) 'PF ANGLE(deg):',PFANG,STD(1),'12. EQUIV O.D.(in):',OD
     *IA
   16 FORMAT(4X,A14,1X,F5.2,1X,A8,11X,A19,1X,F6.3)
      WRITE(1,18) 'CL ANGLE(deg):',CLANG,STD(2),'13. ENGAGEMENT LENGTH(i
     *n):',LE
   18 FORMAT(4X,A14,1X,F5.2,1X,A8,11X,A26,1X,F5.2)
      WRITE(1,20) 'EXT ROOT RADIUS(in):',ERR,STD(3),'14. INTERRUPTED THR
     *D FACTOR:',SECTOR
   20 FORMAT(4X,A20,1X,F5.4,1X,A9,4X,A28,1X,F5.3)
      WRITE(1,22) 'INT ROOT RADIUS(in):',IRR,STD(4),'15. LOAD FACTOR(1-4
     *,1.5nom):',TLCF
   22 FORMAT(4X,A20,1X,F5.4,1X,A9,4X,A28,1X,F4.2)
      WRITE(1,*) ' '
      WRITE(1,24) '16. T.S. EXT MEMBER(ksi):',ETS,'17. T.S. INT MEMBER(
     *ksi):',ITS
   24 FORMAT(A25,1X,F6.2,5X,A25,1X,F6.2)
      WRITE(1,24) '18. Y.S. EXT MEMBER(ksi):',EYS,'19. Y.S. INT MEMBER(
     *ksi):',IYS
      WRITE(1,26) '20. SURF EXT MEMBER:',ESURFS,'21. SURF INT MEMBER:',I
```

```
 *SURFS
26 FORMAT(A20,1X,A15,1X,A20,1X,A15)
   WRITE(1,*) ' '
   WRITE(1,28) 'EXTERNAL THREAD','SPEC(in)','DEV(in)','VAR(%)'
28 FORMAT(3X,A15,11X,A4,15X,A3,13X,A3)
   EJTOL=EJX-EJN
   EPTOL=EPX-EPN
   EMTOL=EMX-EMN
   IJTOL=IJX-IJN
   IPTOL=IPX-IPN
   IMTOL=IMX-IMN
   WRITE(1,30) '22. MAJOR DIA(in):',EJX,'-',EJTOL,EJA,EJV
30 FORMAT(A17,9X,F7.4,A1,F5.4,7X,F7.4,9X,F7.5)
   WRITE(1,30) '23. PITCH DIA(in):',EPX,'-',EPTOL,EPA,EPV
   WRITE(1,30) '24. MINOR DIA(in):',EMX,'-',EMTOL,EMA,EMV
   WRITE(1,28) 'INTERNAL THREAD','SPEC','DEV','VAR'
   WRITE(1,30) '25. MAJOR DIA(in):',IJN,'+',IJTOL,IJA,IJV
   WRITE(1,30) '26. PITCH DIA(in):',IPN,'+',IPTOL,IPA,IPV
   WRITE(1,30) '27. MINOR DIA(in):',IMN,'+',IMTOL,IMA,IMV
   WRITE(1,*) ' '
   WRITE(1,32) '28. APPLIED PRELOAD(kip):',LOAD(1),'DECIMAL OF MAX AL
  *LOWABLE:',FPFRAC
32 FORMAT(A25,1X,F8.2,7X,A25,1X,F4.2)
   WRITE(1,34) 'APPROX TIGHTENING TORQUE(ft-lb):',TORQ,'FRICTION FACT
  *OR:',FF
34 FORMAT(4X,A32,1X,F8.2,9X,A16,1X,F4.2)
   WRITE(1,36) '29. AXIAL LOAD(kip):',LOAD(2),'(max)',LOAD(3),'(min)'
36 FORMAT(A20,1X,F8.2,1X,A5,2X,F8.2,1X,A5)
   WRITE(1,38) '30. INTERNAL PRESSURE(ksi):',PRES(1)
38 FORMAT(A27,1X,F8.2)
   WRITE(1,40) '31. TEMPERATURE(deg F):',TEMP,'32. FATIGUE DATA REL:'
  *,REL
40 FORMAT(A23,1X,I4,14X,A21,1X,F5.4)
   WRITE(1,*) ' '
   IF(SARV.GT.30.) THEN
     WRITE(1,*) 'NOTE:  THREAD SURFACE CONTACT AREA HAS BEEN REDUCED
  *MORE THAN '
     WRITE(1,*) '30% OF MIN SPEC CONDITION.  SPECIAL CONSIDERATION MA
  *Y BE REQUIRED.'
     ENDIF
   IF(SERIES.EQ.2.OR.SERIES.EQ.3) THEN
     WRITE(1,*) 'NOTE:  THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.'
     WRITE(1,50) 'BL TO SPEC: ',BLS,' BL TO DEV: ',BLD
50   FORMAT(A12,F5.4,10X,A12,F5.4)
     ENDIF
   WRITE(1,*)
   RETURN
   END
```

```
C
C ***********************************************************************
C ***           SUBROUTINE TO CHECK FOR INTERFERENCES                 ***
C ***********************************************************************
C
      SUBROUTINE INTCHK
      REAL*4 G1,G2
      CHARACTER*3 RETN
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      INTFLG=0
      IF(EJA.EQ.0.) G1=EJX
      IF(EJA.NE.0.) G1=EJA
      IF(IJA.EQ.0.) G2=IJN
      IF(IJA.NE.0.) G2=IJA
      IF(G1.GT.G2) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '               *** INTERFERENCE CONDITION ***'
        WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
     * MAJOR DIAMETERS'
        WRITE(1,*) ' '
        INTFLG=1
        ENDIF
      IF(EPA.EQ.0.) G1=EPX
      IF(EPA.NE.0.) G1=EPA
      IF(IPA.EQ.0.) G2=IPN
      IF(IPA.NE.0.) G2=IPA
      IF(G1.GT.G2) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '               *** INTERFERENCE CONDITION ***'
        WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
     * PITCH DIAMETERS'
        WRITE(1,*) ' '
        INTFLG=1
        ENDIF
      IF(EMA.EQ.0.) G1=EMX
      IF(EMA.NE.0.) G1=EMA
      IF(IMA.EQ.0.) G2=IMN
      IF(IMA.NE.0.) G2=IMA
      IF(G1.GT.G2) THEN
        WRITE(1,*) ' '
        WRITE(1,*) '               *** INTERFERENCE CONDITION ***'
        WRITE(1,5) INT(1000*(G1-G2)+.5)/1000,'IN INTERFERENCE AT THREAD
     * MINOR DIAMETERS'
        WRITE(1,*) ' '
        INTFLG=1
        ENDIF
  5   FORMAT(F7.4,2X,A42)
      IF(INTFLG.EQ.1) THEN
       CALL TNOUA('     PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
       READ(1,30) RETN
       IF(RETN.NE.' ') RETURN
 30    FORMAT(A1)
       ENDIF
      RETURN
       END
```

```
C
C ***********************************************************************
C ***       SUBROUTINE TO CALCULATE BACKLASH CONDITIONS               ***
C ***********************************************************************
C
C  This calculation assumes perfect thread formulation as per the
C  H28 specifications.
C
      SUBROUTINE BKLASH
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      BLPFS=(IPX-EPN)*TAN(PFRAD) /*BACKLASH PRESSURE FACE SIDE: TO SPEC
      BLCFS=(IPX-EPN)*TAN(CLRAD) /*BACKLASH CLEARANC FACE SIDE: TO SPEC
      IF(IPA.EQ.0) THEN
        Q1=IPX
      ELSE
        Q1=IPA
        ENDIF
      IF(EPA.EQ.0) THEN
        Q2=EPN
      ELSE
        Q2=EPN
        ENDIF
      BLPFD=(Q1-Q2)*TAN(PFRAD) /*BACKLASH PRESSURE FACE SIDE: ACTUAL
      BLCFD=(Q1-Q2)*TAN(CLRAD) /*BACKLASH CLEARANC FACE SIDE: ACTUAL
      BLS=BLPFS+BLCFS            /*BACKLASH TOTAL: TO SPEC
      BLD=BLPFD+BLCFD            /*BACKLASH TOTAL: ACTUAL
      RETURN
      END
```

```
C
C ***********************************************************************
C ***    SUBROUTINE TO CALCULATE VARIANCES FROM TO SPEC GEO            ***
C ***********************************************************************
C
      SUBROUTINE PCVAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      CHARACTER*2 RET
C *** VARIANCE OF MAJOR DIA ON EXTERNAL THREAD ***
      IF(EJA.LT.EJN.AND.EJA.NE.0.) EJV=EJA-EJN
      IF(EJA.EQ.0.) EJV=0.
      IF(EJA.LE.EJX.AND.EJA.GE.EJN) EJV=0.
      IF(EJA.GT.EJX) EJV=EJA-EJX
C *** VARIANCE OF PITCH DIA ON EXTERNAL THREAD ***
      IF(EPA.LT.EPN.AND.EPA.NE.0.) EPV=EPA-EPN
      IF(EPA.EQ.0.) EPV=0.
      IF(EPA.LE.EPX.AND.EPA.GE.EPN) EPV=0.
      IF(EPA.GT.EPX) EPV=EPA-EPX
C *** VARIANCE OF MINOR DIA ON EXTERNAL THREAD ***
      IF(EMA.LT.EMN.AND.EMA.NE.0.) EMV=EMA-EMN
      IF(EMA.EQ.0.) EMV=0.
      IF(EMA.LE.EMX.AND.EMA.GE.EMN) EPV=0.
      IF(EMA.GT.EMX) EMV=EMA-EMX
C *** VARIANCE OF MAJOR DIA ON INTERNAL THREAD ***
      IF(IJA.LT.IJN.AND.IJA.NE.0.) IJV=IJA-IJN
      IF(IJA.EQ.0.) IJV=0.
      IF(IJA.LE.IJX.AND.IJA.GE.IJN) IJV=0.
      IF(IJA.GT.IJX) IJV=IJA-IJX
C *** VARIANCE OF PITCH DIA ON INTERNAL THREAD ***
      IF(IPA.LE.IPN.AND.IPA.NE.0.) IPV=IPA-IPX
      IF(IPA.EQ.0.) IPV=0.
      IF(IPA.LE.IPX.AND.IPA.GE.IPN) IPV=0.
      IF(IPA.GT.IPX) IPV=IPA-IPX
C *** VARIANCE OF MINOR DIA ON INTERNAL THREAD ***
      IF(IMA.LE.IMN.AND.IMA.NE.0.) IMV=IMA-IMN
      IF(IMA.EQ.0.) IMV=0.
      IF(IMA.LE.IMX.AND.IMA.GE.IMN) IMV=0.
      IF(IMA.GT.IMX) IMV=IMA-IMX
      IF(SARA.GT.SARX) THEN
        SARV=100.*(INTL((10000.*(SARA-SARX)/SARX)+.5)/10000.)
        ENDIF
      IF(SARA.LT.SARN) THEN
        SARV=100.*(INTL((10000.*(SARA-SARN)/SARN)+.5)/10000.)
        ENDIF
      IF(SARA.GE.SARN.AND.SARA.LE.SARX) SARV=0.
      RETURN
      END
```

```
C
C **********************************************************************
C ***     SUBROUTINE TO PRESENT CLASS MENU AND SELECTION             ***
C **********************************************************************
C
      SUBROUTINE TCLASS
      INTEGER*4 PICK
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      IF(SERIES.EQ.1) THEN      /* V-THREAD SERIES
        WRITE(1,*) ' '
        WRITE(1,*) '*** UNIFIED NATIONAL THREAD CLASSES ***'
        WRITE(1,*) ' '
        WRITE(1,*) '      CLASS 1 .................. 1'
        WRITE(1,*) '      CLASS 2 .................. 2'
        WRITE(1,*) '      CLASS 3 .................. 3'
        WRITE(1,*) ' '
        CALL TNOUA('ENTER: ',INTS(7))
 10     READ(1,'(I1)',ERR=10) PICK
        IF(PICK.EQ.1) CLASS='1 '
        IF(PICK.EQ.2) CLASS='2 '
        IF(PICK.EQ.3) CLASS='3 '
        ENDIF
      IF(SERIES.EQ.2) THEN     /* ACME SERIES
        WRITE(1,*) ' '
        WRITE(1,*) '***      ACME THREAD CLASSES     ***'
        WRITE(1,*) ' '
        WRITE(1,*) '(1) CLASS 2G            (4) CLASS 2C'
        WRITE(1,*) '(2) CLASS 3G            (5) CLASS 3C'
        WRITE(1,*) '(3) CLASS 4G            (6) CLASS 4C'
        WRITE(1,*) '                        (7) CLASS 5C'
        WRITE(1,*) '                        (8) CLASS 6C'
        WRITE(1,*) ' '
 20     CALL TNOUA('ENTER: ',INTS(7))
        READ(1,'(I1)',ERR=20) PICK
        IF(PICK.EQ.1) CLASS='2G'
        IF(PICK.EQ.2) CLASS='3G'
        IF(PICK.EQ.3) CLASS='4G'
        IF(PICK.EQ.4) CLASS='2C'
        IF(PICK.EQ.5) CLASS='3C'
        IF(PICK.EQ.6) CLASS='4C'
        IF(PICK.EQ.7) CLASS='5C'
        IF(PICK.EQ.8) CLASS='6C'
        ENDIF
      IF(SERIES.EQ.3) THEN     /* STUB ACME SERIES
        WRITE(1,*) ' '
        WRITE(1,*) '***    STUB ACME CLASSES     ***'
        WRITE(1,*) ' '
```

```
      WRITE(1,*) 'CLASS 1 (Std Stub Acme Form) ..... 1'
      WRITE(1,*) 'CLASS 2 (Modified Form 1 Stub) ... 2'
      WRITE(1,*) 'CLASS 3 (Modified Form 2 Stub) ... 3'
      WRITE(1,*)
30    CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=30) PICK
      IF(PICK.EQ.1) CLASS='1 '
      IF(PICK.EQ.2) CLASS='2 '
      IF(PICK.EQ.3) CLASS='3 '
      ENDIF
    IF(SERIES.EQ.4) THEN   /* BUTTRESS SERIES
      WRITE(1,*) ' '
      WRITE(1,*) '***   STANDARD BUTTRESS CLASSES   ***'
      WRITE(1,*) ' '
      WRITE(1,*) '      CLASS 1 ................ 1'
      WRITE(1,*) '      CLASS 2 ................ 2'
      WRITE(1,*) '      CLASS 3 ................ 3'
      WRITE(1,*) ' '
40    CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=40) PICK
      IF(PICK.EQ.1) CLASS='1 '
      IF(PICK.EQ.2) CLASS='2 '
      IF(PICK.EQ.3) CLASS='3 '
      IF(PICK.LT.1.OR.PICK.GT.4) GOTO 40
      ENDIF
    IF(SERIES.EQ.5) THEN     /* PF20 SPECIAL THREAD
      CLASS='- '
      ENDIF
    RETURN
    END
```

```
C
C ****************************************
C ***   STAITC AND FATIGUE ANALYSIS   ***
C ****************************************
C
      SUBROUTINE CALCU
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
      WRITE(1,*) 'CALL SURFAR'
      CALL SURFAR
      WRITE(1,*) 'CALL SAREA'
      CALL SAREA
      WRITE(1,*) 'CALL TORSION'
      CALL TORSION
      WRITE(1,*) 'CALL LDHIST'
      CALL LDHIST
      WRITE(1,*) 'CALL STATSF'
      CALL STATSF
      IF(SDFLAG.EQ.1) THEN
      DO 20 I=1,7
      DO 10 J=1,7
      FSF(I,J)=0.
   10 CONTINUE
   20 CONTINUE
      ENDIF
      IF(SDFLAG.EQ.2) THEN
      WRITE(1,*) 'CALL NOTCH'
      CALL NOTCH
      WRITE(1,*) 'CALL TSCF'
      CALL TSCF
      WRITE(1,*) 'CALL FATIGUE'
      CALL FATIGUE
      ENDIF
      WRITE(1,*) 'CALL FOUTPT'
      CALL FOUTPT
      RETURN
      END
```

```
C
C ************************************************************************
C ***   SUBROUTINE TO RECALCULATE THREAD GEOMETRY & ANALYSIS RESULTS ***
C ************************************************************************
C
      SUBROUTINE RECALC
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      IF(SERIES.EQ.1) CALL H28VEE
      IF(SERIES.EQ.2) CALL H28ACM
      IF(SERIES.EQ.3) CALL H28STB
      IF(SERIES.EQ.4) CALL H28BUT
      IF(SERIES.EQ.5) CALL PF20
      RETURN
      END
```

```
C
C ***********************************************************************
C ***   SUBROUTINE TO CALCULATE THREAD SURFACE CONTACT AREAS            ***
C ***********************************************************************
C
      SUBROUTINE SURFAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      HELIXS=((PI*IPN)**2.+PITCH**2.)**.5/PITCH*LE
      SARX=HELIXS*((EJX-IMN)/COS(PFRAD))*.5
      SARN=HELIXS*((EJN-IMX)/COS(PFRAD))*.5
      IF(EJA.GT.EJX.OR.(EJA.LT.EJN.AND.EJA.NE.0)) G1=EJA
      IF((EJA.LE.EJX.AND.EJA.GE.EJN).OR.EJA.EQ.0) G1=EJN
      IF(IMA.GT.IMX.OR.(IMA.LT.IMN.AND.IMA.NE.0)) G2=IMA
      IF((IMA.LE.IMX.AND.IMA.GE.IMN).OR.IMA.EQ.0) G2=IMN
      SARA=HELIXS*((G1-G2)/COS(PFRAD))*.5
      RETURN
      END
```

```
C
C ***********************************************************************
C ***   SUBROUTINE TO CALCULATE STRESS AREA  AT                        ***
C ***********************************************************************
C
      SUBROUTINE SAREA
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      REAL*4 HO
      IF(SERIES.EQ.1) HO=.48*PITCH
      IF(SERIES.EQ.2) HO=.5*PITCH
      IF(SERIES.EQ.3) HO=.3*PITCH
      IF(SERIES.EQ.4) HO=.6*PITCH
      IF(SERIES.EQ.5) THEN
        IF(PITCH.EQ..5) HO=.24
        IF(PITCH.EQ..75) HO=.359
        IF(PITCH.EQ..375) HO=.1795
        IF(PITCH.EQ..25) HO=.12
        ENDIF
      AT=(PI/4.)*(IPN-3.*HO/4.)**2.
      RETURN
      END
```

```
C
C ***********************************************************************
C ***   SUBROUTINE TO INPUT/EDIT THREAD JOINT PRELOAD                ***
C ***********************************************************************
C
      SUBROUTINE PRELOD
      INTEGER*4 CHOICE
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      EXTERNAL TNOUA
      WRITE(1,*) ' '
      WRITE(1,*) '*** SELECT APPROPRIATE PRELOAD ***'
      WRITE(1,*) ' '
      WRITE(1,*) 'PRELOAD AMOUNT'
      WRITE(1,*) 'NONE .............. 1'
      WRITE(1,*) 'FULL .............. 2'
      WRITE(1,*) 'PARTIAL ........... 3'
      WRITE(1,*) 'BY LOAD .. ........ 4'
      WRITE(1,*) 'BY TORQUE ......... 5'
  120 CALL TNOUA('ENTER: ',INTS(7))
      READ(1,'(I1)',ERR=120) CHOICE
      CALL SAREA
      PREMAX=.9*YS*AT         /* MAX RECOMMENDED PRELOAD (W/O PLASTIC)
      IF(CHOICE.EQ.1) THEN
        LOAD(1)=0.
        FF=.2
        TORQ=0.
        FPFRAC=0.
        ENDIF
      IF(CHOICE.EQ.2) THEN
        LOAD(1)=PREMAX
  121   CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
        READ(1,'(F4.3)',ERR=121) FF
        FPFRAC=1.
        TORQ=LOAD(1)*1000.*EJN*FF/12.
        ENDIF
      IF(CHOICE.EQ.3) THEN
        WRITE(1,*) ' '
  122   CALL TNOUA('ENTER DECIMAL FRACTION: ',INTS(24))
        READ(1,'(F4.3)',ERR=122) FPFRAC
        LOAD(1)=PREMAX*FPFRAC
  123   CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
        READ(1,'(F4.3)',ERR=123) FF
        TORQ=LOAD(1)*1000.*EJN*FF/12.
```

```
      ENDIF
    IF(CHOICE.EQ.4) THEN
      WRITE(1,*) ' '
124   CALL TNOUA('ENTER PRELOAD OR CLAMPING LOAD (kip): ',INTS(38))
      READ(1,*,ERR=124) LOAD(1)
      IF(LOAD(1).GT.PREMAX) THEN
        WRITE(1,*) 'Preload given is beyond the approximate elastic'
        WRITE(1,125) 'limit of the specified material:',PREMAX,'(kip)'
125   FORMAT(A32,1X,F5.1,A5)
        GOTO 124
        ENDIF
126   CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
      READ(1,'(F4.3)',ERR=126) FF
      FPFRAC=LOAD(1)/PREMAX
      TORQ=LOAD(1)*1000.*FF*EJN/12.
      ENDIF
    IF(CHOICE.EQ.5) THEN
      WRITE(1,*) ' '
      WRITE(1,*) 'CAUTION: Determining preload by tightening torque'
      WRITE(1,*) 'can only be considered as a rough approximation.'
      WRITE(1,*) 'Experimental verification of actual conditions '
      WRITE(1,*) 'should be applied for critical applications.'
      WRITE(1,*) ' '
130   CALL TNOUA('ENTER FRICTION FACTOR(.2-DRY,.15-LUB): ',INTS(39))
      READ(1,'(F4.3)',ERR=130) FF
140   CALL TNOUA('ENTER APPLIED TORQUE(FT-LBS): ',INTS(30))
      READ(1,*,ERR=140) TORQ
      LOAD(1)=TORQ/(EJN*FF)*12./1000.
      IF(LOAD(1).GT.PREMAX) THEN
        TORQMAX=PREMAX*1000.*EJN*FF/12.
        WRITE(1,*) 'Preload induced by given torque exceeds linear '
        WRITE(1,*) 'elastic range of specified material.  '
        WRITE(1,142) 'Maximum Recommended Torque:',TORQMAX,'(ft-lb)'
142     FORMAT(A27,1X,F8.2,A7)
        GOTO 140
        ENDIF
      FPFRAC=LOAD(1)/PREMAX
      ENDIF
    RETURN
    END
```

```
C
C ************************************************************************
C *** SUBROUTINE TO CALC TORSIONAL STRESS DUE TO TIGHTENING & PRELOAD **
C ************************************************************************
C
      SUBROUTINE TORSION
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      YS=AMIN1(EYS,IYS)   /* FIND MINUMUM YIELD STRESS
      PREMAX=.9*YS*AT
      TPE=(.16/PI)*PREMAX*EJX*EMN/(EMN**4.-HDIA**4.)
      TPI=(.16/PI)*PREMAX*ODIA*IMN/(ODIA**4.-IMN**4.)
      RETURN
      END
```

```
C
C ***********************************************************************
C  **           SUBROUTINE TO EVALUATE LOAD HISTORY PARAMETERS        ***
C ***********************************************************************
C
      SUBROUTINE LDHIST
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
C  CALCULATE STRESS DUE TO PRELOAD CONDITION
C
      DO 2 I=1,12
      DO 1 J=1,2
      S(I,J)=0.
    1 CONTINUE
    2 CONTINUE
      IF(LOAD(1).EQ.0.) THEN
        ESPX=0.
        ESPN=0.
        ESPA=0.
        ISPX=0.
        ISPN=0.
        ISPA=0.
        GOTO 10
        ENDIF
      APPLD=LOAD(1)
      WRITE(1,*) 'CALL HOOP'
      CALL HOOP
      WRITE(1,*) 'CALL SSHEAR'
      CALL SSHEAR
      WRITE(1,*) 'CALL AXSCF'
      CALL AXSCF
      WRITE(1,*) 'CALL HEYWD'
      CALL HEYWD
      WRITE(1,*) 'CALL OCT'
      CALL OCT
      ESPX=SOCTEX
      ESPN=SOCTEN
      ESPA=SOCTEA
      ISPX=SOCTIX
      ISPN=SOCTIN
      ISPA=SOCTIA
C
C  CALCULATE STRESSES DUE TO GIVEN MAX & MIN LOADS
C  AND GIVEN MAX & MIN INTERNAL PRESSURES (IF ANY)
C
   10 DO 20 I=1,2
      APPLD=LOAD(I+1)
      IPRES=PRES(1)
```

```
      WRITE(1,*) 'CALL HOOP'
      CALL HOOP
      WRITE(1,*) 'CALL SSHEAR'
      CALL SSHEAR
      WRITE(1,*) 'CALL AXSCF'
      CALL AXSCF
      WRITE(1,*) 'CALL HEYWD'
      CALL HEYWD
      WRITE(1,*) 'CALL OCT'
      CALL OCT
      S(1,I)=SOCTEX
      S(2,I)=SOCTEN
      S(3,I)=SOCTEA
      S(4,I)=SOCTIX
      S(5,I)=SOCTIN
      S(6,I)=SOCTIA
      S(7,I)=TOCTEX
      S(8,I)=TOCTEN
      S(9,I)=TOCTEA
      S(10,I)=TOCTIX
      S(11,I)=TOCTIN
      S(12,I)=TOCTIA
      IF(LOAD(3).EQ.0.) GOTO 30
   20 CONTINUE
   30 MEAN(1)=(ESPX+(S(1,1)+S(1,2))/2.)*100./ETS
      MEAN(2)=(ESPN+(S(2,1)+S(2,2))/2.)*100./ETS
      MEAN(3)=(ESPA+(S(3,1)+S(3,2))/2.)*100./ETS
      MEAN(4)=(ISPX+(S(4,1)+S(4,2))/2.)*100./ITS
      MEAN(5)=(ISPN+(S(5,1)+S(5,2))/2.)*100./ITS
      MEAN(6)=(ISPA+(S(6,1)+S(6,2))/2.)*100./ITS
      ALT(1)=((S(1,1)-S(1,2))/2.)*100./ETS
      ALT(2)=((S(2,1)-S(2,2))/2.)*100./ETS
      ALT(3)=((S(3,1)-S(3,2))/2.)*100./ETS
      ALT(4)=((S(4,1)-S(4,2))/2.)*100./ITS
      ALT(5)=((S(5,1)-S(5,2))/2.)*100./ITS
      ALT(6)=((S(6,1)-S(6,2))/2.)*100./ITS
      RETURN
      END
```

```
C
C ************************************************************************
C ***     SUBROUTINE TO CALCULATE HOOP STRESS ON EXTERNAL MEMBER        ***
C ************************************************************************
C
      SUBROUTINE HOOP
      REAL*4 G1
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      SHEX=(2.*PRES(1)*(HDIA)**2.)/(EMX**2.-HDIA**2.)
      SHEN=(2.*PRES(1)*(HDIA)**2.)/(EMN**2.-HDIA**2.)
      IF((EMA.GE.EMN.AND.EMA.LE.EMX).OR.EMA.EQ.0.) G1=EMN
      IF((EMA.LT.EMN.AND.EMA.NE.0.).OR.EMA.GT.EMX) G1=EMA
      SHEA=(2.*PRES(1)*(HDIA)**2.)/(G1**2.-HDIA**2.)
      RETURN
      END
```

```
C
C **********************************************************************
C *** SUBROUTINE TO CALCULATE SHEAR AREAS AND STRENGTHS              ***
C **********************************************************************
C
      SUBROUTINE SSHEAR
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C     ETS - EXTERNAL MEMBER TENSILE STRENGTH
C     ITS - INTERNAL MEMBER TENSILE STRENGTH
      IF(ETS.EQ.ITS) THEN                    /* EQUAL INT & EXT STRENGTH
        HELIXS=N*LE*((PI*IPN)**2.+PITCH**2.)**.5
        ASHEAR=HELIXS/(2.*N)
        ENDIF
      IF(ETS.GT.ITS) THEN                    /* EXT STRENGTH GREATER
        HELIXS=N*LE*((PI*EJN)**2.+PITCH**2.)**.5
        ASHEAR=.5*HELIXS*(PITCH+(TAN(PFRAD)+TAN(CLRAD))*(EJN-IPX))
        ENDIF
      IF(ITS.GT.ETS) THEN                    /* INT STRENGTH GREATER
        HELIXS=N*LE*((PI*IMX)**2.+PITCH**2.)**.5
        ASHEAR=.5*HELIXS*(PITCH+(TAN(PFRAD)+TAN(CLRAD))*(EPN-IMX))
        ENDIF
      SSTRESS=LOAD(2)/ASHEAR
      RETURN
      END
```

```
C
C ************************************************************************
C ***  SUBROUTINE TO CALCULATE AXIAL STRESS CONCENTRATION FACTOR       ***
C ***  AND FILLET STRESS AT THREAD ROOT AREA DUE TO AXIAL LOAD         ***
C ************************************************************************
C
      SUBROUTINE AXSCF
      REAL*4 GAMMA,WVAR1,WVAR2,WVAR3,K1,W0,W1,W2,K2
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      GAMMA=.3*(PITCH/HE1)**.7
      WVAR1=((GAMMA*HE1/ERR)**.5)*.6
      WVAR2=((((EMN-HDIA)/(2.*ERR))**.5)*6.)-1.
      WVAR3=4*GAMMA*HE1/ERR
      K1=WVAR1*WVAR2/((WVAR3+.09*(WVAR2)**2.)**.5)
      W0=1.-((PFANG+CLANG)/180.)**(1.+2.4*(ERR/(GAMMA*HE1))**.5)
      W1=((EMX/2./ERR)**.5)-1.
      W2=((EMN/2./ERR)**.5)-1.
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) G1=EMA
      IF((EMA.LE.EMX.AND.EMA.GE.EMN).OR.EMA.EQ.0.) G1=EMN
      W3=((G1/2./ERR)**.5)-1.
      KAEX=1.+((1.25*(K1-1.)*W1*W0)/((K1-1.)**2.+1.5625*W1**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KAEN=1.+((1.25*(K1-1.)*W2*W0)/((K1-1.)**2.+1.5625*W2**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KAEA=1.+((1.25*(K1-1.)*W3*W0)/((K1-1.)**2.+1.5625*W3**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KNEX=1.+((1.25*(K1-1.)*W1*W0)/((K1-1.)**2.+1.5625*W1**2.)**.5)
      IF(KAEX.LT.1.) KAEX=1.
      IF(KAEN.LT.1.) KAEN=1.
      IF(KAEA.LT.1.) KAEA=1.
      STEX=KAEX*APPLD*(4./PI)/(EMX**2.-HDIA**2.)
      STEN=KAEN*APPLD*(4./PI)/(EMN**2.-HDIA**2.)
      STEA=KAEA*APPLD*(4./PI)/(G1**2.-HDIA**2.)
      GAMMA=.3*(PITCH/HI1)**.7
      WVAR1=((GAMMA*HI1/IRR)**.5)*.6
      WVAR2=((((ODIA-IJX)/(2.*IRR))**.5)*6.)-1
      WVAR3=4*GAMMA*HI1/IRR
      K2=WVAR1*WVAR2/((WVAR3+.09*(WVAR2)**2.)**.5)
      W0=1.-((PFANG+CLANG)/180.)**(1.+2.4*(IRR/(GAMMA*HI1))**.5)
      W1=1.667*((IJN/2./IRR)**.5)-.5
      W2=1.667*((IJX/2./IRR)**.5)-.5
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.0.)) G1=IJA
      IF(IJA.EQ.0..OR.(IJA.LE.IJX.AND.IJA.GE.IJN)) G1=IJX
```

```
      W3=1.667*((G1/2./IRR)**.5)-.5
      KAIX=1.+((K2-1.)*W1*WO/((K2-1.)**.2+W1**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KAIN=1.+((K2-1.)*W2*WO/((K2-1.)**.2+W2**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KAIA=1.+((K2-1.)*W3*WO/((K2-1.)**.2+W3**2.)**.5)*COS
     *(2.*PI/3.-2.*PFRAD)
      KNIX=1.+((K2-1.)*W1*WO/((K2-1.)**.2+W1**2.)**.5)
      IF(KAIX.LT.1.) KAIX=1.
      IF(KAIN.LT.1.) KAIN=1.
      IF(KAIA.LT.1.) KAIA=1.
      STIX=KAIX*APPLD*(4./PI)/(ODIA**2.-IJN**2.)
      STIN=KAIN*APPLD*(4./PI)/(ODIA**2.-IJX**2.)
      STIA=KAIA*APPLD*(4./PI)/(ODIA**2.-G1**2.)
      RETURN
      END
```

```
C
C **********************************************************************
C *** SUBROUTINE TO CALCULATE VARIABLES USED IN HEYWOOD'S EQUATION   ***
C **********************************************************************
C
      SUBROUTINE HEYWD
      REAL*4 V,V2,V3,U1,U2,U3,G1,U4
     *D1EX,D1EN,D1EA,D1IX,D1IN,D1IA,P0,U5,U6,U7,U8,Y,Z,
     *SBEX(7),SBEN(7),SBEA(7),SBIX(7),SBIN(7),SBIA(7)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
C
C     CALCULATION OF E PARAMETER
C
      V=(1.-COS((PI/3.)-PFRAD))
      V2=SIN((PFRAD+CLRAD)/2.)
      V3=COS(PFRAD)
      EEX=((HV-SEMAX-ERR*V)/V3)*V2
      EEN=((HV-SEMIN-ERR*V)/V3)*V2
      EEA=((HV-SEMIN-ERR*V)/V3)*V2
      EIX=((HV-SIMAX-IRR*V)/V3)*V2
      EIN=((HV-SIMIN-IRR*V)/V3)*V2
      EIA=((HV-SIMIN-IRR*V)/V3)*V2
C
C     CALCULATION OF M1
C
      U1=TAN(PI/4.-(PFRAD/2.))+TAN(PI/4.-(CLRAD/2.))-SIN(PI/3.-(PFRAD))
     *-SIN(PI/3.-CLRAD)
      U2=PITCH/2.
      U3=TAN(PFRAD)+TAN(CLRAD)
      M1EX=ERR*U1+U2+U3*(EPX-EMX)*.5
      M1EN=ERR*U1+U2+U3*(EPN-EMN)*.5
      IF(EPA.GT.EPX.OR.(EPA.LT.EPN.AND.EPA.NE.0.)) Z1=EPA
      IF((EPA.LE.EPX.AND.EPA.GE.EPN).OR.EPA.EQ.0.) Z1=EPN
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) Z2=EMA
      IF((EMA.LE.EMX.AND.EMA.GE.EMN).OR.EMA.EQ.0.) Z2=EMN
      G1=(Z1-Z2)*.5
      M1EA=ERR*U1+U2+U3*G1
      M1IX=IRR*U1+U2+U3*(IJN-IPN)*.5
      M1IN=IRR*U1+U2+U3*(IJX-IPX)*.5
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.0.)) Z1=IJA
      IF((IJA.LE.IJX.AND.IJA.GE.IJN).OR.IJA.EQ.0.) Z1=IJX
      IF(IPA.GT.IPX.OR.(IPA.LT.IPN.AND.IPA.NE.0.)) Z2=IPA
      IF((IPA.LE.IPX.AND.IPA.GE.IPN).OR.IPA.EQ.0.) Z2=IPX
      G1=(Z1-Z2)*.5
      M1IA=IRR*U1+U2+U3*G1
C
C      CALCULATE VALUES FOR THETA
C
```

```
      IF(SERIES.EQ.4.OR.SERIES.EQ.5) THEN
      U4=COS(PI/3.-CLRAD)-COS(PI/3.-PFRAD)
      ETHETAX=ATAN((ERR*U4)/M1EX)
      ETHETAN=ATAN((ERR*U4)/M1EN)
      ETHETAA=ATAN((ERR*U4)/M1EA)
      ITHETAX=ATAN((IRR*U4)/M1IX)
      ITHETAN=ATAN((IRR*U4)/M1IN)
      ITHETAA=ATAN((IRR*U4)/M1IA)
C
C     CALCULATE VALUES FOR D1
C
      D1EX=M1EX/COS(ETHETAX)
      D1EN=M1EN/COS(ETHETAN)
      D1EA=M1EA/COS(ETHETAA)
      D1IX=M1IX/COS(ITHETAX)
      D1IN=M1IN/COS(ITHETAN)
      D1IA=M1IA/COS(ITHETAA)
      ELSE
      D1EX=M1EX
      D1EN=M1EN
      D1EA=M1EA
      D1IX=M1IX
      D1IN=M1IN
      D1IA=M1IA
      ENDIF
C
C     CALCULATE VALUES FOR D' (EXT THRD)
C
      PO=(EJN-IMX)*.05*COS(PFRAD)
      DPEX(1)=(EJX-IMN)/4.+(IMN-EMX)/2.
      DPEN(1)=(EJN-IMX)/4.+(IMX-EMN)/2.
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) G1=EMA
      IF(EMA.EQ.0..OR.(EMA.LE.EMX.AND.EMA.GE.EMN)) G1=EMN
      DPEA(1)=(EJN-IMX)/4.+(IMX-G1)/2.
      DPEX(2)=DPEX(1)+PO*.5629
      DPEN(2)=DPEN(1)+PO*.5629
      DPEA(2)=DPEA(1)+PO*.5629
      DPEX(3)=DPEX(1)-PO*.5629
      DPEN(3)=DPEN(1)-PO*.5629
      DPEA(3)=DPEA(1)-PO*.5629
      DPEX(4)=DPEX(1)+PO*1.11974
      DPEN(4)=DPEN(1)+PO*1.11974
      DPEA(4)=DPEA(1)+PO*1.11974
      DPEX(5)=DPEX(1)-PO*1.11974
      DPEN(5)=DPEN(1)-PO*1.11974
      DPEA(5)=DPEA(1)-PO*1.11974
      DPEX(6)=DPEX(1)+PO*1.6241
      DPEN(6)=DPEN(1)+PO*1.6241
      DPEA(6)=DPEA(1)+PO*1.6241
      DPEX(7)=DPEX(1)-PO*1.6241
```

```
      DPEN(7)=DPEN(1)-PO*1.6241
      DPEA(7)=DPEA(1)-PO*1.6241
C
C     CALCULATE HELIX AT POINT OF APPLIED LOAD
C
      PTX(1)=N*LE*((PI*(EMX+2.*DPEX(1)))**2.+PITCH**2.)**.5
      PTN(1)=N*LE*((PI*(EMN+2.*DPEN(1)))**2.+PITCH**2.)**.5
      PTA(1)=N*LE*((PI*(G1+2.*DPEA(1)))**2.+PITCH**2.)**.5
      PTX(2)=N*LE*((PI*(EMX+2.*DPEX(2)))**2.+PITCH**2.)**.5
      PTN(2)=N*LE*((PI*(EMN+2.*DPEN(2)))**2.+PITCH**2.)**.5
      PTA(2)=N*LE*((PI*(G1+2.*DPEA(2)))**2.+PITCH**2.)**.5
      PTX(3)=N*LE*((PI*(EMX+2.*DPEX(3)))**2.+PITCH**2.)**.5
      PTN(3)=N*LE*((PI*(EMN+2.*DPEN(3)))**2.+PITCH**2.)**.5
      PTA(3)=N*LE*((PI*(G1+2.*DPEA(3)))**2.+PITCH**2.)**.5
      PTX(4)=N*LE*((PI*(EMX+2.*DPEX(4)))**2.+PITCH**2.)**.5
      PTN(4)=N*LE*((PI*(EMN+2.*DPEN(4)))**2.+PITCH**2.)**.5
      PTA(4)=N*LE*((PI*(G1+2.*DPEA(4)))**2.+PITCH**2.)**.5
      PTX(5)=N*LE*((PI*(EMX+2.*DPEX(5)))**2.+PITCH**2.)**.5
      PTN(5)=N*LE*((PI*(EMN+2.*DPEN(5)))**2.+PITCH**2.)**.5
      PTA(5)=N*LE*((PI*(G1+2.*DPEA(5)))**2.+PITCH**2.)**.5
      PTX(6)=N*LE*((PI*(EMX+2.*DPEX(6)))**2.+PITCH**2.)**.5
      PTN(6)=N*LE*((PI*(EMN+2.*DPEN(6)))**2.+PITCH**2.)**.5
      PTA(6)=N*LE*((PI*(G1+2.*DPEA(6)))**2.+PITCH**2.)**.5
      PTX(7)=N*LE*((PI*(EMX+2.*DPEX(7)))**2.+PITCH**2.)**.5
      PTN(7)=N*LE*((PI*(EMN+2.*DPEN(7)))**2.+PITCH**2.)**.5
      PTA(7)=N*LE*((PI*(G1+2.*DPEA(7)))**2.+PITCH**2.)**.5
C
C     CALCULATE VALUES FOR D' (INT THRD)
C
      DPIX(1)=(IJN-EJX)/2.+(EJX-IMN)/4.
      DPIN(1)=(IJX-EJN)/2.+(EJN-IMX)/4.
      IF((IJA.LT.IJN.AND.IJA.NE.O.).OR.IJA.GT.IJN) G1=IJA
      IF(IJA.EQ.O..OR.(IJA.LE.IJX.AND.IJA.GE.IJN)) G1=IJX
      DPIA(1)=(G1-EJN)/2.+(EJN-IMX)/4.
      DPIX(2)=DPIX(1)+PO*.5629
      DPIN(2)=DPIN(1)+PO*.5629
      DPIA(2)=DPIA(1)+PO*.5629
      DPIX(3)=DPIX(1)-PO*.5629
      DPIN(3)=DPIN(1)-PO*.5629
      DPIA(3)=DPIA(1)-PO*.5629
      DPIX(4)=DPIX(1)+PO*1.11974
      DPIN(4)=DPIN(1)+PO*1.11974
      DPIA(4)=DPIA(1)+PO*1.11974
      DPIX(5)=DPIX(1)-PO*1.11974
      DPIN(5)=DPIN(1)-PO*1.11974
      DPIA(5)=DPIA(1)-PO*1.11974
      DPIX(6)=DPIX(1)+PO*1.6241
      DPIN(6)=DPIN(1)+PO*1.6241
      DPIA(6)=DPIA(1)+PO*1.6241
      DPIX(7)=DPIX(1)-PO*1.6241
```

```
      DPIN(7)=DPIN(1)-PO*1.6241
      DPIA(7)=DPIA(1)-PO*1.6241
C     CALCULATION OF B & A
      U5=TAN(PI/4.-PFRAD/2.)
      U6=SIN(PI/3.-PFRAD)
      U7=TAN(PFRAD)
      U8=COS(PFRAD)
      Y=ERR
      Z=IRR
      DO 10 I=1,7
      BEX(I)=(DPEX(I)-Y*V)/COS(ATAN((DPEX(I)*U7+Y*U5-Y*U6)/(DPEX(I)-Y*V)
     *))
      BEN(I)=(DPEN(I)-Y*V)/COS(ATAN((DPEN(I)*U7+Y*U5-Y*U6)/(DPEN(I)-Y*V)
     *))
      BEA(I)=(DPEA(I)-Y*V)/COS(ATAN((DPEA(I)*U7+Y*U5-Y*U6)/(DPEA(I)-Y*V)
     *))
      BIX(I)=(DPIX(I)-Z*V)/COS(ATAN((DPIX(I)*U7+Z*U5-Z*U6)/(DPIX(I)-Z*V)
     *))
      BIN(I)=(DPIN(I)-Z*V)/COS(ATAN((DPIN(I)*U7+Z*U5-Z*U6)/(DPIN(I)-Z*V)
     *))
      BIA(I)=(DPIA(I)-Z*V)/COS(ATAN((DPIA(I)*U7+Z*U5-Z*U6)/(DPIA(I)-Z*V)
     *))
      AEX(I)=(DPEX(I)-Y*U6)/U8-SIN(PFRAD+ETHETAX)*(D1EX/2.-Y*(U5-U6))
      AEN(I)=(DPEN(I)-Y*U6)/U8-SIN(PFRAD+ETHETAN)*(D1EN/2.-Y*(U5-U6))
      AEA(I)=(DPEA(I)-Y*U6)/U8-SIN(PFRAD+ETHETAA)*(D1EA/2.-Y*(U5-U6))
      AIX(I)=(DPIX(I)-Z*U6)/U8-SIN(PFRAD+ITHETAX)*(D1IX/2.-Z*(U5-U6))
      AIN(I)=(DPIN(I)-Z*U6)/U8-SIN(PFRAD+ITHETAN)*(D1IN/2.-Z*(U5-U6))
      AIA(I)=(DPIA(I)-Z*U6)/U8-SIN(PFRAD+ITHETAA)*(D1IA/2.-Z*(U5-U6))
10    CONTINUE
C
C     CALCULATE KB (FILLET STRESS CONCENTRATION FACTOR)
C
      KBEX=(1.+.26*(EEX/Y))**.7
      KBEN=(1.+.26*(EEN/Y))**.7
      KBEA=(1.+.26*(EEA/Y))**.7
      KBIX=(1.+.26*(EIX/Z))**.7
      KBIN=(1.+.26*(EIN/Z))**.7
      KBIA=(1.+.26*(EIA/Z))**.7
C
C     CALCULATE SECOND COEFF TERM IN HEYWOOD EQ
C
      T1X(1)=.2128*APPLD/PTX(1)/COS(PFRAD)
      T1N(1)=.2128*APPLD/PTN(1)/COS(PFRAD)
      T1A(1)=.2128*APPLD/PTA(1)/COS(PFRAD)
      T1X(2)=.1953*APPLD/PTX(2)/COS(PFRAD)
      T1N(2)=.1953*APPLD/PTN(2)/COS(PFRAD)
      T1A(2)=.1953*APPLD/PTA(2)/COS(PFRAD)
      T1X(3)=.1953*APPLD/PTX(3)/COS(PFRAD)
      T1N(3)=.1953*APPLD/PTN(3)/COS(PFRAD)
      T1A(3)=.1953*APPLD/PTA(3)/COS(PFRAD)
```

```
      T1X(4)=.1428*APPLD/PTX(4)/COS(PFRAD)
      T1N(4)=.1428*APPLD/PTN(4)/COS(PFRAD)
      T1A(4)=.1428*APPLD/PTA(4)/COS(PFRAD)
      T1X(5)=.1428*APPLD/PTX(5)/COS(PFRAD)
      T1N(5)=.1428*APPLD/PTN(5)/COS(PFRAD)
      T1A(5)=.1428*APPLD/PTA(5)/COS(PFRAD)
      T1X(6)=.0554*APPLD/PTX(6)/COS(PFRAD)
      T1N(6)=.0554*APPLD/PTN(6)/COS(PFRAD)
      T1A(6)=.0554*APPLD/PTA(6)/COS(PFRAD)
      T1X(7)=.0554*APPLD/PTX(7)/COS(PFRAD)
      T1N(7)=.0554*APPLD/PTN(7)/COS(PFRAD)
      T1A(7)=.0554*APPLD/PTA(7)/COS(PFRAD)
C
C     CALCULATE 1ST TERM INSIDE BRACKETS IN HEYWOODS EQUATION
C
      DO 20 I=1,7
      T2EX(I)=1.5*AEX(I)/EEX**2.
      T2EN(I)=1.5*AEN(I)/EEN**2.
      T2EA(I)=1.5*AEA(I)/EEA**2.
      T2IX(I)=1.5*AIX(I)/EIX**2.
      T2IN(I)=1.5*AIN(I)/EIN**2.
      T2IA(I)=1.5*AIA(I)/EIA**2.
C
C     CALCULATE 2ND TERM INSIDE BRACKETS IN HEYWOOD EQUATION
C
      T3EX(I)=.45/(BEX(I)*EEX)**.5
      T3EN(I)=.45/(BEN(I)*EEN)**.5
      T3EA(I)=.45/(BEA(I)*EEA)**.5
      T3IX(I)=.45/(BIX(I)*EIX)**.5
      T3IN(I)=.45/(BIN(I)*EIN)**.5
      T3IA(I)=.45/(BIA(I)*EIA)**.5
C
C     CALCULATE 3RD TERM INSIDE BRACKETS IN HEYWOOD EQUATION
C
      T4EX(I)=.5/(2.*EEX)   /* NOTE: FOR LOAD NORMAL TO PF, PHI=30
      T4EN(I)=.5/(2.*EEN)
      T4EA(I)=.5/(2.*EEA)
      T4IX(I)=.5/(2.*EIX)
      T4IN(I)=.5/(2.*EIN)
      T4IA(I)=.5/(2.*EIA)
C
C     CALCULATE ROOT STRESS FORM VALUES
C
      SBEX(I)=KBEX*T1X(I)*(T2EX(I)+T3EX(I)+T4EX(I))
      SBEN(I)=KBEN*T1N(I)*(T2EN(I)+T3EN(I)+T4EN(I))
      SBEA(I)=KBEA*T1A(I)*(T2EA(I)+T3EA(I)+T4EA(I))
      SBIX(I)=KBIX*T1N(I)*(T2IX(I)+T3IX(I)+T4IX(I))
      SBIN(I)=KBIN*T1X(I)*(T2IN(I)+T3IN(I)+T4IN(I))
      SBIA(I)=KBIA*T1A(I)*(T2IA(I)+T3IA(I)+T4IA(I))
   20 CONTINUE
```

```
C
C     CALCULATE COMBINED TOTAL SB DUE TO PARABOLIC LOAD DISTRIBUTION
C
      SBEXT=SBEX(1)+SBEX(2)+SBEX(3)+SBEX(4)+SBEX(5)+SBEX(6)+SBEX(7)
      SBEXT=TLCF*SBEXT
      SBENT=SBEN(1)+SBEN(2)+SBEN(3)+SBEN(4)+SBEN(5)+SBEN(6)+SBEN(7)
      SBENT=TLCF*SBENT
      SBEAT=SBEA(1)+SBEA(2)+SBEA(3)+SBEA(4)+SBEA(5)+SBEA(6)+SBEA(7)
      SBEAT=TLCF*SBEAT
      SBIXT=SBIX(1)+SBIX(2)+SBIX(3)+SBIX(4)+SBIX(5)+SBIX(6)+SBIX(7)
      SBIXT=TLCF*SBIXT
      SBINT=SBIN(1)+SBIN(2)+SBIN(3)+SBIN(4)+SBIN(5)+SBIN(6)+SBIN(7)
      SBINT=TLCF*SBINT
      SBIAT=SBIA(1)+SBIA(2)+SBIA(3)+SBIA(4)+SBIA(5)+SBIA(6)+SBIA(7)
      SBIAT=TLCF*SBIAT
      RETURN
      END
```

```
C
C **********************************************************************
C ***  SUBROUTINE TO CALC HYDROSTATIC TENSION & PURE SHEAR ON AN      ***
C ***                         OCTAHEDRAL PLANE                       ***
C **********************************************************************
C
      SUBROUTINE OCT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      SOCTEX=(1./3.)*(SBEXT+STEX+SHEX)
      SOCTEN=(1./3.)*(SBENT+STEN+SHEN)
      SOCTEA=(1./3.)*(SBEAT+STEA+SHEA)
      SOCTIX=(1./3.)*(SBIXT+STIX)
      SOCTIN=(1./3.)*(SBINT+STIN)
      SOCTIA=(1./3.)*(SBIAT+STIA)
      TOCTEX=(1./3.)*(SBEXT+STEX-SHEX)
      TOCTEN=(1./3.)*(SBENT+STEN-SHEN)
      TOCTEA=(1./3.)*(SBEAT+STEA-SHEA)
      TOCTIX=(1./3.)*(SBIXT+STIX)
      TOCTIN=(1./3.)*(SBINT+STIN)
      TOCTIA=(1./3.)*(SBIAT+STIA)
      RETURN
      END
```

```
C
C **********************************************************************
C **  SUBROUTINE TO CALCULATE STATIC SAFETY FACTORS WRT Y.S & T.S.   ***
C **                AND LOAD CAPACITIES                              ***
C **********************************************************************
C
      SUBROUTINE STATSF
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      SF1YEX=EYS/S(1,1)
      SF1YEN=EYS/S(2,1)
      SF1YEA=EYS/S(3,1)
      SF1YIX=IYS/S(4,1)
      SF1YIN=IYS/S(5,1)
      SF1YIA=IYS/S(6,1)
      SF2YEX=.577*EYS/S(7,1)
      SF2YEN=.577*EYS/S(8,1)
      SF2YEA=.577*EYS/S(9,1)
      SF2YIX=.577*IYS/S(10,1)
      SF2YIN=.577*IYS/S(11,1)
      SF2YIA=.577*IYS/S(12,1)
      SF1TEX=ETS/S(1,1)
      SF1TEN=ETS/S(2,1)
      SF1TEA=ETS/S(3,1)
      SF1TIX=ITS/S(4,1)
      SF1TIN=ITS/S(5,1)
      SF1TIA=ITS/S(6,1)
      SF2TEX=.577*ETS/S(7,1)
      SF2TEN=.577*ETS/S(8,1)
      SF2TEA=.577*ETS/S(9,1)
      SF2TIX=.577*ITS/S(10,1)
      SF2TIN=.577*ITS/S(11,1)
      SF2TIA=.577*ITS/S(12,1)
      SFYEX=AMIN1(SF1YEX,SF2YEX)
      SFYEN=AMIN1(SF1YEN,SF2YEN)
      SFYEA=AMIN1(SF1YEA,SF2YEA)
      SFYIX=AMIN1(SF1YIX,SF2YIX)
      SFYIN=AMIN1(SF1YIN,SF2YIN)
      SFYIA=AMIN1(SF1YIA,SF2YIA)
      SFTEX=AMIN1(SF1TEX,SF2TEX)
      SFTEN=AMIN1(SF1TEN,SF2TEN)
      SFTEA=AMIN1(SF1TEA,SF2TEA)
      SFTIX=AMIN1(SF1TIX,SF2TIX)
      SFTIN=AMIN1(SF1TIN,SF2TIN)
      SFTIA=AMIN1(SF1TIA,SF2TIA)
      SFY=AMIN1(SFYEX,SFYEN,SFYEA,SFYIX,SFYIN,SFYIA)
      SFT=AMIN1(SFTEX,SFTEN,SFTEA,SFTIX,SFTIN,SFTIA)
      CAPPLD(1)=LOAD(2)*SFYEX
      CAPPLD(2)=LOAD(2)*SFTEX
```

```
      CAPPLD(3)=LOAD(2)*SFYEN
      CAPPLD(4)=LOAD(2)*SFTEN
      CAPPLD(5)=LOAD(2)*SFYEA
      CAPPLD(6)=LOAD(2)*SFTEA
      CAPPLD(7)=LOAD(2)*SFYIX
      CAPPLD(8)=LOAD(2)*SFTIX
      CAPPLD(9)=LOAD(2)*SFYIN
      CAPPLD(10)=LOAD(2)*SFTIN
      CAPPLD(11)=LOAD(2)*SFYIA
      CAPPLD(12)=LOAD(2)*SFTIA
      CAPPLD(13)=AMIN1(CAPPLD(1),CAPPLD(3),CAPPLD(5),CAPPLD(7),CAPPLD(9)
     *,CAPPLD(11))
      CAPPLD(14)=AMIN1(CAPPLD(2),CAPPLD(4),CAPPLD(6),CAPPLD(8),CAPPLD(10
     *),CAPPLD(12))
      LDYE=EYS/SSTRESS*LOAD(2)
      LDYI=IYS/SSTRESS*LOAD(2)
      LDTE=ETS/SSTRESS*LOAD(2)
      LDTI=ITS/SSTRESS*LOAD(2)
      RETURN
      END
```

```
C
C ************************************************************************
C ***  SUBROUTINE TO GENERATE NOTCH SENSITIVITY FACTORS GIVEN RADIUS ***
C ***              AND ULTIMATE STRENGTH OF THE MATERIAL             ***
C ************************************************************************
C
      SUBROUTINE NOTCH
      REAL*4 ARR(16,11)
      INTEGER*4 EC,IC
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      DATA ((ARR(I,J), I=1,16), J=1,11)/.0025,.005,.0075,.01,.015,.02,.0
     *3,.04,.05,.06,.07,.08,.1,.12,.14,.16,.741,.808,.835,.855,.881,.894
     *,.91,.92,.926,.932,.938,.944,.949,.954,.957,.963,.680,.756,.785,.8
     *10,.840,.855,.876,.890,.9,.908,.915,.922,.929,.935,.94,.945,.62,.7
     *03,.735,.764,.798,.815,.843,.861,.873,.883,.892,.901,.908,.917,.92
     *2,.926,.559,.651,.685,.719,.757,.776,.809,.831,.847,.859,.869,.879
     *,.888,.898,.904,.908,.494,.592,.632,.666,.706,.730,.765,.791,.810,
     *.824,.837,.846,.918,.926,.931,.935,.429,.532,.58,.613,.656,.684,.7
     *24,.751,.774,.79,.805,.814,.831,.843,.853,.86,.386,.468,.522,.553,
     *.599,.632,.678,.712,.735,.754,.766,.778,.798,.813,.833,.835,.356,.
     *42,.467,.496,.542,.574,.623,.659,.686,.704,.721,.737,.758,.775,.78
     *5,.797,.257,.347,.398,.434,.482,.519,.569,.607,.633,.655,.672,.688
     *,.709,.726,.739,.752,.079,.18,.247,.295,.366,.417,.491,.546,.582,.
     *615,.641,.667,.723,.76,.789,.81/
C
C     SELECT PROPER NOTCH SENSITIVITY CURVES BASED ON MAT'L STRENGTHS
C
      IF(ETS.GT.200.) EC=2
      IF(ETS.GE.180..AND.ETS.LT.200.) EC=3
      IF(ETS.GE.160..AND.ETS.LT.180.) EC=4
      IF(ETS.GE.140..AND.ETS.LT.160.) EC=5
      IF(ETS.GE.120..AND.ETS.LT.140.) EC=6
      IF(ETS.GE.100..AND.ETS.LT.120.) EC=7
      IF(ETS.GE.80..AND.ETS.LT.100.)  EC=8
      IF(ETS.GE.60..AND.ETS.LT.80.)   EC=9
      IF(ETS.GE.50..AND.ETS.LT.60.)   EC=10
      IF(ITS.GT.200.) IC=2
      IF(ITS.GE.180..AND.ITS.LT.200.) IC=3
      IF(ITS.GE.160..AND.ITS.LT.180.) IC=4
      IF(ITS.GE.140..AND.ITS.LT.160.) IC=5
      IF(ITS.GE.120..AND.ITS.LT.140.) IC=6
      IF(ITS.GE.100..AND.ITS.LT.120.) IC=7
      IF(ITS.GE.80..AND.ITS.LT.100.)  IC=8
```

```
      IF(ITS.GE.60..AND.ITS.LT.80.)   IC=9
      IF(ITS.GE.50..AND.ITS.LT.60.)   IC=10
C
C     EVALUATE NOTCH SENSITIVITY VALUES (EXTERNAL THREAD)
C
      IF(ERR.LT..0025) THEN
        EQ=(ARR(1,EC)/.0025)*ERR
        GOTO 30
        ENDIF
      DO 10, I=2,16
      IF(ERR.GE.ARR(I-1,1).AND.ERR.LT.ARR(I,1)) GOTO 20
   10 CONTINUE
      WRITE(1,*) 'ERROR IN SUBROUTINE NOTCH.'
      STOP
   20 EQ=ARR(I-1,EC)+((ARR(I,EC)-ARR(I-1,EC))/(ARR(I,1)-ARR(I-1,1)))*(ER
     *R-ARR(I-1,1))
C
C     EVALUATE NOTCH SENSITIVITY VALUES (INTERNAL THREAD)
C
   30 IF(IRR.LT..0025) THEN
        IQ=(ARR(1,IC)/.0025)*IRR
        GOTO 70
        ENDIF
      DO 40, I=2,16
      IF(IRR.GE.ARR(I-1,1).AND.IRR.LT.ARR(I,1)) GOTO 60
   40 CONTINUE
      WRITE(1,*) 'ERROR IN SUBROUTINE NOTCH.'
      STOP
   60 IQ=ARR(I-1,IC)+((ARR(I,IC)-ARR(I-1,IC))/(ARR(I,1)-ARR(I-1,1)))*(IR
     *R-ARR(I-1,1))
   70 RETURN
      END
```

```
C
C ************************************************************************
C *** SUBROUTINE TO CALCULATE THEORECTICAL STRESS CONCENTRATION FACT ***
C ***         AND MOD FACTOR DUE TO FATIGUE STRESS CONC FACTOR        ***
C ************************************************************************
C
      SUBROUTINE TSCF
      REAL*4 KTC(31,2)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      DATA ((KTC(I,J),I=1,31),J=1,2)/.01,.015,.02,.025,.03,.035,.04,.045
     *,.05,.055,.06,.065,.07,.075,.08,.085,.09,.095,.1,.11,.12,.13,.14,.
     *15,.16,.17,.18,.19,.2,.25,.3,3.,2.9,2.65,2.55,2.4,2.3,2.2,2.1,2.05
     *,2.,1.92,1.9,1.85,1.8,1.77,1.75,1.72,1.7,1.68,1.63,1.6,1.57,1.54,1
     *.51,1.48,1.46,1.45,1.43,1.41,1.3,1.26/
      IF(ERR/EMN.LT..01) THEN
        KNEX=3.
        GOTO 30
        ENDIF
      DO 10, I=1,30
      IF(ERR/EMN.GE.KTC(I,1).AND.ERR/EMN.LT.KTC(I+1,1)) GOTO 20
   10 CONTINUE
      STOP
   20 KNEX=KTC(I,2)
   30 IF(IRR/IMN.LT..01) THEN
        KNIX=3.
        GOTO 60
        ENDIF
      DO 40, I=1,30
      IF(IRR/IMN.GE.KTC(I,1).AND.IRR/IMN.LT.KTC(I+1,1)) GOTO 50
   40 CONTINUE
      STOP
   50 KNIX=KTC(I,2)
   60 KQEX=1.+EQ*(KNEX-1.)
      KQEN=1.+EQ*(KNEX-1.)
      KQEA=1.+EQ*(KNEX-1.)
      KQIX=1.+IQ*(KNIX-1.)
      KQIN=1.+IQ*(KNIX-1.)
      KQIA=1.+IQ*(KNIX-1.)
      KPEX=(KQEX-1.)*(.12+.0038*(ETS-100.))+1.
      KPEN=(KQEN-1.)*(.12+.0038*(ETS-100.))+1.
      KPEA=(KQEA-1.)*(.12+.0038*(ETS-100.))+1.
      KPIX=(KQIX-1.)*(.12+.0038*(ITS-100.))+1.
      KPIN=(KQIN-1.)*(.12+.0038*(ITS-100.))+1.
      KPIA=(KQIA-1.)*(.12+.0038*(ITS-100.))+1.
      KFEX(1)=KPEX
      KFEN(1)=KPEN
      KFEA(1)=KPEA
      KFIX(1)=KPIX
```

```
KFIN(1)=KPIN
KFIA(1)=KPIA
KFEX(2)=KPEX+(KQEX-KPEX)*(ALOG10(3000.)-3.)/3.
KFEN(2)=KPEN+(KQEN-KPEN)*(ALOG10(3000.)-3.)/3.
KFEA(2)=KPEA+(KQEA-KPEA)*(ALOG10(3000.)-3.)/3.
KFIX(2)=KPIX+(KQIX-KPIX)*(ALOG10(3000.)-3.)/3.
KFIN(2)=KPIN+(KQIN-KPIN)*(ALOG10(3000.)-3.)/3.
KFIA(2)=KPIA+(KQIA-KPIA)*(ALOG10(3000.)-3.)/3.
KFEX(3)=KPEX+(KQEX-KPEX)/3.
KFEN(3)=KPEN+(KQEN-KPEN)/3.
KFEA(3)=KPEA+(KQEA-KPEA)/3.
KFIX(3)=KPIX+(KQIX-KPIX)/3.
KFIN(3)=KPIN+(KQIN-KPIN)/3.
KFIA(3)=KPIA+(KQIA-KPIA)/3.
KFEX(4)=KPEX+(KQEX-KPEX)*(ALOG10(40000.)-3.)/3.
KFEN(4)=KPEN+(KQEN-KPEN)*(ALOG10(40000.)-3.)/3.
KFEA(4)=KPEA+(KQEA-KPEA)*(ALOG10(40000.)-3.)/3.
KFIX(4)=KPIX+(KQIX-KPIX)*(ALOG10(40000.)-3.)/3.
KFIN(4)=KPIN+(KQIN-KPIN)*(ALOG10(40000.)-3.)/3.
KFIA(4)=KPIA+(KQIA-KPIA)*(ALOG10(40000.)-3.)/3.
KFEX(5)=KPEX+(KQEX-KPEX)*2./3.
KFEN(5)=KPEN+(KQEN-KPEN)*2./3.
KFEA(5)=KPEA+(KQEA-KPEA)*2./3.
KFIX(5)=KPIX+(KQIX-KPIX)*2./3.
KFIN(5)=KPIN+(KQIN-KPIN)*2./3.
KFIA(5)=KPIA+(KQIA-KPIA)*2./3.
KFEX(6)=KQEX
KFEN(6)=KQEN
KFEA(6)=KQEA
KFIX(6)=KQIX
KFIN(6)=KQIN
KFIA(6)=KQIA
KFEX(7)=KQEX
KFEN(7)=KQEN
KFEA(7)=KQEA
KFIX(7)=KQIX
KFIN(7)=KQIN
KFIA(7)=KQIA
RETURN
END
```

```
C
C ************************************************************************
C ***   SUBROUTINE TO CALCULATE FATIGUE LIFE SAFETY FACTORS           ***
C ************************************************************************
C
C    SUBROUTINE USED NEWTON METHOD TO FIND INTERCEPT OF LIFE LINE AND
C    SLOPE LINE.  2ND DEGREE POLYNOMIALS ARE USED TO DESCRIBE DATA CURVES
C
      SUBROUTINE FATIGUE
      REAL*4 C(7,3),SL(6)
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
      DATA ((C(I,J),I=1,7),J=1,3)/83.6204,75.574,67.1299,61.0005,
     *55.1154,48.4214,46.2044,-.648158,-.471915,-.314665,-.245179,
     *-.24794,-.287679,-.313033,-.00188942,-.00284203,-.0035522,
     *-.00360573,-.00303571,-.00205357,-.00156593/
      DO 40 I=1,6              /* MAT'L CONDITIONS
      SL(I)=ATAN(ALT(I)/MEAN(I))
      DO 30 J=1,7              /* FATIGUE LIFE CURVES
      X1=((SL(I)-C(J,2))+((C(J,2)-SL(I))**2-4.*C(J,3)*C(J,1))**.5)/(2.*
     *C(J,3))
      X2=((SL(I)-C(J,2))-((C(J,2)-SL(I))**2-4.*C(J,3)*C(J,1))**.5)/(2.*
     *C(J,3))
      X=AMAX1(X1,X2)
   20 YVAL=(C(J,3)*X**2+C(J,2)*X+C(J,1))
      IF(I.LE.3) THEN
        YVAL=YVAL*ETS/100.
      ELSE
        YVAL=YVAL*ITS/100.
        ENDIF
   30 CONTINUE
   40 CONTINUE
C     LOAD CONSTANT
      CL=.9         /* REVERSED AXIAL LOADS W/O BENDING
C     SIZE EFFECT
      CD=1.0        /* AXIAL LOAD
C     SURFACE FINISH EFFECT
C     MIRROR-POLISHED FINISH
      IF(ESURF.EQ.1) ECF=1.
      IF(ISURF.EQ.1) ICF=1.
C     FINE GROUND FINISH
      IF(ESURF.EQ.2.AND.ETS.LE.170.) ECF=.9
      IF(ISURF.EQ.2.AND.ITS.LE.170.) ICF=.9
      IF(ESURF.EQ.2.AND.ETS.GT.170.) ECF=-.002*ETS+1.24
      IF(ISURF.EQ.2.AND.ITS.GT.170.) ICF=-.002*ITS+1.24
C     MACHINED FINISH
      IF(ESURF.EQ.3.AND.ETS.LE.200.) ECF=-.0012*ETS+.87
      IF(ISURF.EQ.3.AND.ITS.LE.200.) ICF=-.0012*ITS+.87
      IF(ESURF.EQ.3.AND.ETS.GT.200.) ECF=-.002*ETS+1.06
```

```
      IF(ISURF.EQ.3.AND.ITS.GT.200.) ICF=-.002*ITS+1.06
C     HOT ROLLED FINISH
      IF(ESURF.EQ.4.AND.ETS.LE.140.) ECF=-.0035*ETS+.95
      IF(ISURF.EQ.4.AND.ITS.LE.140.) ICF=-.0035*ITS+.95
      IF(ESURF.EQ.4.AND.ETS.GT.140.) ECF=-.0018*ETS+.72
      IF(ISURF.EQ.4.AND.ITS.GT.140.) ICF=-.0018*ITS+.72
C     FORGED FINISH
      IF(ESURF.EQ.5.AND.ETS.LE.120.) ECF=-.0037*ETS+.77
      IF(ISURF.EQ.5.AND.ITS.LE.120.) ICF=-.0037*ITS+.77
      IF(ESURF.EQ.5.AND.ETS.GT.120.) ECF=-.0016*ETS+.567
      IF(ISURF.EQ.5.AND.ITS.GT.120.) ICF=-.0016*ITS+.567
      IF(ESURF.EQ.1) ESURFS='MIRROR POLISH'
      IF(ISURF.EQ.1) ISURFS='MIRROR POLISH'
      IF(ESURF.EQ.2) ESURFS='FINE GROUND  '
      IF(ISURF.EQ.2) ISURFS='FINE GROUND  '
      IF(ESURF.EQ.3) ESURFS='MACHINED     '
      IF(ISURF.EQ.3) ISURFS='MACHINED     '
      IF(ESURF.EQ.4) ESURFS='HOT ROLLED   '
      IF(ISURF.EQ.4) ISURFS='HOT ROLLED   '
      IF(ESURF.EQ.5) ESURFS='FORGED       '
      IF(ISURF.EQ.5) ISURFS='FORGED       '
C     TEMPERATURE EFFECT
      IF(TEMP.GT.160.) CT=620./(460.+TEMP)
      IF(TEMP.LE.160.) CT=1.
C     RELIABILITY FACTOR
      IF(REL.EQ..5) CR=1.
      IF(REL.EQ..9) CR=.897
      IF(REL.EQ..95) CR=.868
      IF(REL.EQ..99) CR=.814
      IF(REL.EQ..999) CR=.753
C     ESTIMATED SAFETY FACTORS FOR VARIOUS FATIGUE LIFE
      FSF(1,1)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(1)
      FSF(1,2)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(2)
      FSF(1,3)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(3)
      FSF(1,4)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(4)
      FSF(1,5)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(5)
      FSF(1,6)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(6)
      FSF(1,7)=CD*ECF*CL*CT*CR*YVAL/ALT(1)/KFEX(7)
      FSF(2,1)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(1)
      FSF(2,2)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(2)
      FSF(2,3)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(3)
      FSF(2,4)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(4)
      FSF(2,5)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(5)
      FSF(2,6)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(6)
      FSF(2,7)=CD*ECF*CL*CT*CR*YVAL/ALT(2)/KFEN(7)
      FSF(3,1)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(1)
      FSF(3,2)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(2)
      FSF(3,3)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(3)
      FSF(3,4)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(4)
      FSF(3,5)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(5)
```

```
      FSF(3,6)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(6)
      FSF(3,7)=CD*ECF*CL*CT*CR*YVAL/ALT(3)/KFEA(7)
      FSF(4,1)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(1)
      FSF(4,2)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(2)
      FSF(4,3)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(3)
      FSF(4,4)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(4)
      FSF(4,5)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(5)
      FSF(4,6)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(6)
      FSF(4,7)=CD*ICF*CL*CT*CR*YVAL/ALT(4)/KFIX(7)
      FSF(5,1)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(1)
      FSF(5,2)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(2)
      FSF(5,3)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(3)
      FSF(5,4)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(4)
      FSF(5,5)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(5)
      FSF(5,6)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(6)
      FSF(5,7)=CD*ICF*CL*CT*CR*YVAL/ALT(5)/KFIN(7)
      FSF(6,1)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(1)
      FSF(6,2)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(2)
      FSF(6,3)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(3)
      FSF(6,4)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(4)
      FSF(6,5)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(5)
      FSF(6,6)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(6)
      FSF(6,7)=CD*ICF*CL*CT*CR*YVAL/ALT(6)/KFIA(7)
      FSF(7,1)=AMIN1(FSF(1,1),FSF(2,1),FSF(3,1),FSF(4,1),FSF(5,1),FSF(6,
     *1))
      FSF(7,2)=AMIN1(FSF(1,2),FSF(2,2),FSF(3,2),FSF(4,2),FSF(5,2),FSF(6,
     *2))
      FSF(7,3)=AMIN1(FSF(1,3),FSF(2,3),FSF(3,3),FSF(4,3),FSF(5,3),FSF(6,
     *3))
      FSF(7,4)=AMIN1(FSF(1,4),FSF(2,4),FSF(3,4),FSF(4,4),FSF(5,4),FSF(6,
     *4))
      FSF(7,5)=AMIN1(FSF(1,5),FSF(2,5),FSF(3,5),FSF(4,5),FSF(5,5),FSF(6,
     *5))
      FSF(7,6)=AMIN1(FSF(1,6),FSF(2,6),FSF(3,6),FSF(4,6),FSF(5,6),FSF(6,
     *6))
      FSF(7,7)=AMIN1(FSF(1,7),FSF(2,7),FSF(3,7),FSF(4,7),FSF(5,7),FSF(6,
     *7))
C     ESTIMATED ENDURANCE LIMITS
      ESE=CD*ECF*CL*CT*CR*.5*ETS/KQEN
      ISE=CD*ICF*CL*CT*CR*.5*ITS/KQIN
      RETURN
      END
```

```
C
C ************************************************************************
C ***    SUBROUTINE TO PROVIDE STATIC + FATIGUE ANALYSIS OUTPUT        ***
C ************************************************************************
C
      SUBROUTINE FOUTPT
$INSERT CB1.THRD
$INSERT CB2.THRD
$INSERT CB3.THRD
$INSERT SYSCOM>A$KEYS
$INSERT SYSCOM>KEYS.F
      CHARACTER*34 TSTR
      CHARACTER*8  STR1,STR2
      EXTERNAL TNOUA
      CALL TNOUA(:115614,INTS(4))
      WRITE(1,*) '                    *** THREADED JOINT STRESS ANALYSIS RESUL
     *TS ***'
      WRITE(1,*) ' '
      IF(SERIES.EQ.5) THEN
        WRITE(STR1,'(F6.3)') IJN
        LEN1=INTL(NLEN$A(STR1,INTS(8)))
        WRITE(STR2,'(F5.4)') PITCH
        LEN2=INTL(NLEN$A(STR2,INTS(8)))
        LEN3=INTL(NLEN$A(SERSTR,INTS(10)))
        TSTR='THREAD TYPE: '//STR1(1:LEN1)//'-'//SERSTR(1:LEN3)//'-'//
     *STR2(1:LEN2)
       LEN4=INTL(NLEN$A(TSTR,INTS(34)))
       GOTO 10
       ENDIF
      WRITE(STR1,'(F6.3)') BMJDIA
      LEN1=INTL(NLEN$A(STR1,INTS(8)))
      WRITE(STR2,'(I2)') N
      LEN2=INTL(NLEN$A(STR2,INTS(2)))
      LEN3=INTL(NLEN$A(SERSTR,INTS(10)))
      TSTR='THREAD TYPE: '//STR1(1:LEN1)//'-'//STR2(1:LEN2)//' '//
     *SERSTR(1:LEN3)//'-'//CLASS(1:2)
      LEN4=INTL(NLEN$A(TSTR,INTS(34)))
   10 IF(LEN4.LT.34) THEN
   20   TSTR(1:LEN4+1)=TSTR(1:LEN4)//' '
        LEN4=LEN4+1
        IF(LEN4.LT.34) GOTO 20
        ENDIF
      WRITE(1,40) TSTR,'FILE NAME: ',FNAME
   40 FORMAT(A34,10X,A11,A20)
      WRITE(1,50) 'WAIVER NO: ',WVN,'SCN: ',SCN,'PART NO: ',PN
   50 FORMAT(A11,A10,12X,A5,A10,8X,A9,A10)
      WRITE(1,60) 'ANALYSIS : ',METHD,'DATE: ',DATE,'SUBCODE: ',SUBCODE
   60 FORMAT(A11,A14,5X,A6,A10,8X,A9,A10)
      WRITE(1,*) ' '
      WRITE(1,100) 'FLANK ANGLES(deg): PF/CF ',PFANG,'/',CLANG,'   ROOT
```

```
     *RADII(in): EXT/INT ',ERR,'/',IRR
 100  FORMAT(A25,F5.2,A1,F5.2,1X,A27,F5.4,A1,F5.4)
      WRITE(1,140) 'HOLLOW DIA(EXT)(in): ',HDIA,'SECTOR: ',SECTOR,'ENGAG
     *EMENT LENGTH(in): ',LE
 140  FORMAT(A21,F6.3,8X,A8,F5.3,2X,A23,F5.3)
      WRITE(1,160) 'EQUIV O.D.(INT)(in): ',ODIA,'LOAD FACTOR: ',TLCF,'AP
     *PLIED PRELOAD(kip):',LOAD(1)
 160  FORMAT(A21,F6.3,3X,A13,F5.3,3X,A21,F6.1)
      WRITE(1,180) 'INTERNAL PRESS(ksi): ',PRES(1),'TEMP(deg F): ',TEMP,
     *'MAX APPLIED LOAD(kip):',LOAD(2)
 180  FORMAT(A21,F6.3,3X,A13,I5,2X,A22,F6.1)
      WRITE(1,200) 'RELIABILITY(MEAN=0.5): ',REL,'MIN APPLIED LOAD(kip):
     *',LOAD(3)
 200  FORMAT(20X,A23,F5.3,2X,A22,F6.1)
      WRITE(1,*) ' '
      WRITE(1,*) '          TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi
     *)     SURFACE FINISH'
      WRITE(1,220) 'EXTERNAL',ETS,EYS,ESURFS
      WRITE(1,220) 'INTERNAL',ITS,IYS,ISURFS
 220  FORMAT(A8,14X,F5.1,18X,F5.1,12X,A11)
      WRITE(1,*) ' '
      IF(EJA.GT.EJX.OR.(EJA.LT.EJN.AND.EJA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATINC MAJOR DIA(in) EXT THRD = ',EJA,' *******'
      IF(EPA.GT.EPX.OR.(EPA.LT.EPN.AND.EPA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATING PITCH DIA(in) EXT THRD = ',EPA,' *******'
      IF(EMA.GT.EMX.OR.(EMA.LT.EMN.AND.EMA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATING MAJOR DIA(in) EXT THRD = ',EMA,' *******'
      IF(IJA.GT.IJX.OR.(IJA.LT.IJN.AND.IJA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATING MAJOR DIA(in) INT THRD = ',IJA,' *******'
      IF(IPA.GT.IPX.OR.(IPA.LT.IPN.AND.IPA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATING PITCH DIA(in) INT THRD = ',IPA,' *******'
      IF(IMA.GT.IMX.OR.(IMA.LT.IMN.AND.IMA.NE.0.)) WRITE(1,240) '*******
     *            DEVIATING MAJOR DIA(in) INT THRD = ',IMA,' *******'
 240  FORMAT(A53,F7.4,A19)
      WRITE(1,*) ' '
      WRITE(1,242) 'SHEAR CAP (kip) Y.S./T.S.: EXT = ',LDYE,'/',LDTE,'
     * INT= ',LDYI,'/',LDTI
 242  FORMAT(A33,F9.2,A1,F9.2,A8,F9.2,A1,F9.2)
      WRITE(1,*) ' '
      WRITE(1,'(A80)') 'MATL  LOAD CAP(kip)  STATIC SF     SAFETY FACTOR
     *S FOR FATIGUE CYCLE RANGES         '
      WRITE(1,'(A80)') 'COND    YS      TS      YS   TS    1*10E3 3*10E3 1*
     *10E4 4*10E4 1*10E5 1*10E6 1*10E7'
      WRITE(1,*) ' '
      WRITE(1,260) 'EMAX  ',CAPPLD(1),'/',CAPPLD(2),SFYEX,'/',SFTEX,
     *FSF(1,1),FSF(1,2),FSF(1,3),FSF(1,4),FSF(1,5),FSF(1,6),FSF(1,7)
      WRITE(1,260) 'EMIN  ',CAPPLD(3),'/',CAPPLD(4),SFYEN,'/',SFTEN,
     *FSF(2,1),FSF(2,2),FSF(2,3),FSF(2,4),FSF(2,5),FSF(2,6),FSF(2,7)
      WRITE(1,260) 'EACT  ',CAPPLD(5),'/',CAPPLD(6),SFYEA,'/',SFTEA,
     *FSF(3,1),FSF(3,2),FSF(3,3),FSF(3,4),FSF(3,5),FSF(3,6),FSF(3,7)
```

```
      WRITE(1,260) 'IMAX  ',CAPPLD(7),'/',CAPPLD(8),SFYIX,'/',SFTIX,
     *FSF(4,1),FSF(4,2),FSF(4,3),FSF(4,4),FSF(4,5),FSF(4,6),FSF(4,7)
      WRITE(1,260) 'IMIN  ',CAPPLD(9),'/',CAPPLD(10),SFYIN,'/',SFTIN,
     *FSF(5,1),FSF(5,2),FSF(5,3),FSF(5,4),FSF(5,5),FSF(5,6),FSF(5,7)
      WRITE(1,260) 'IACT  ',CAPPLD(11),'/',CAPPLD(12),SFYIA,'/',SFTIA,
     *FSF(6,1),FSF(6,2),FSF(6,3),FSF(6,4),FSF(6,5),FSF(6,6),FSF(6,7)
      WRITE(1,'(A5)') 'OVER-'
      WRITE(1,260) ' ALL  ',CAPPLD(13),'/',CAPPLD(14),SFY,'/',SFT,
     *FSF(7,1),FSF(7,2),FSF(7,3),FSF(7,4),FSF(7,5),FSF(7,6),FSF(7,7)
260   FORMAT(A5,F6.1,A1,F6.1,1X,F5.2,A1,F5.2,1X,7(F7.4))
      WRITE(1,*) ' '
      WRITE(1,*) ' '
      CALL TNOUA('     PRESS RETURN FOR PROGRAM CONTROL MENU',INTS(42))
      READ(1,300) CONT
      IF(CONT.NE.' ') GOTO 400
300   FORMAT(A1)
400   CALL TNOUA(:115614,INTS(4))
      RETURN
      END
```

```
              *** THREADED JOINT STRESS ANALYSIS RESULTS ***

THREAD TYPE:  2.125-12 UN-3                      FILE NAME: THRD.VEE
WAIVER NO: RIW0000               SCN: 0000               PART NO: 10895620
ANALYSIS : Static+Fatigue       DATE: 25JUL84            SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF 30.00/30.00    ROOT RADII(in): EXT/INT .0104/.0104
HOLLOW DIA(EXT)(in):   0.000        SECTOR: 1.000  ENGAGEMENT LENGTH(in): 1.500
EQUIV O.D.(INT)(in):   5.000   LOAD FACTOR: 1.500    APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi):   0.000   TEMP(deg F):   250  MAX APPLIED LOAD(kip):  60.0
                  RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):    0.0

           TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi)     SURFACE FINISH
EXTERNAL             150.0                 120.0              MACHINED
INTERNAL             150.0                 120.0              MACHINED

*******           DEVIATING PITCH DIA(in) INT THRD =  2.0770           *******
*******           DEVIATING MAJOR DIA(in) INT THRD =  2.0500           *******

SHEAR CAP (kip) Y.S./T.S.: EXT =    585.58/  731.98   INT=    585.58/  731.98

MATL  LOAD CAP(kip)  STATIC SF     SAFETY FACTORS FOR FATIGUE CYCLE RANGES
COND    YS     TS     YS   TS   1*10E3 3*10E3 1*10E4 4*10E4 1*10E5 1*10E6 1*10E7

EMAX  155.3/ 194.2  2.59/ 3.24  1.9705 1.7761 1.6027 1.4408 1.3507 1.1671 1.1671
EMIN  161.3/ 201.6  2.69/ 3.36  2.0461 1.8442 1.6643 1.4961 1.4025 1.2119 1.2119
EACT  161.3/ 201.6  2.69/ 3.36  2.0461 1.8442 1.6643 1.4961 1.4025 1.2119 1.2119
IMAX  308.9/ 386.2  5.15/ 6.44  3.9186 3.5319 3.1873 2.8653 2.6860 2.3209 2.3209
IMIN  258.1/ 322.6  4.30/ 5.38  3.2737 2.9507 2.6628 2.3938 2.2440 1.9390 1.9390
IACT  257.8/ 322.3  4.30/ 5.37  3.2701 2.9474 2.6598 2.3911 2.2414 1.9368 1.9368
OVER-
 ALL  155.3/ 194.2  2.59/ 3.24  1.9705 1.7761 1.6027 1.4408 1.3507 1.1671 1.1671

   PRESS RETURN FOR PROGRAM CONTROL MENU
```

```
                  *** THREAD DATA ***

 1. WAIVER NO: RIW0000         2. SCN#: 0000          3. PART NO: 10895620
 4. METHOD: Static+Fatigue     5. DATE MACH: 25JUL84  6. SUBCODE: EXAMPLE
 7. BASIC DIA(in):  2.1250     8. THREADS/IN: 12.00   9. CLASS: 3

10. THREAD FORM: UN                           11. HOLLOW DIA(in):  0.000
    PF ANGLE(deg): 30.00                      12. EQUIV O.D.(in):  5.000
    CL ANGLE(deg): 30.00                      13. ENGAGEMENT LENGTH(in):  1.50
    EXT ROOT RADIUS(in): .0104                14. INTERRUPTED THRD FACTOR: 1.000
    INT ROOT RADIUS(in): .0104                15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 150.00     17. T.S. INT MEMBER( ksi) 150.00
18. Y.S. EXT MEMBER(ksi): 120.00     19. Y.S. INT MEMBER( ksi) 120.00
20. SURF EXT MEMBER: MACHINED        21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD           SPEC              DEV           VAR
22. MAJOR DIA(in)         2.1250-.0114        0.0000        0.00000
23. PITCH DIA(in)         2.0709-.0046        0.0000        0.00000
24. MINOR DIA(in)         2.0228-.0000        0.0000        0.00000
   INTERNAL THREAD           SPEC              DEV           VAR
25. MAJOR DIA(in)         2.1250+.0180        0.0000        0.00000
26. PITCH DIA(in)         2.0709+.0059        2.0770        0.00020
27. MINOR DIA(in)         2.0348+.0100        2.0500        0.00520

28. APPLIED PRELOAD(kip):      0.00      DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):     0.00         FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):      60.00 (max)    0.00 (min)
30. INTERNAL PRESSURE(ksi):      0.00
31. TEMPERATURE(deg F):  250               32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):
```

*** THREADED JOINT STRESS ANALYSIS RESULTS ***

```
THREAD TYPE:  6.500-12 ACME-3C                   FILE NAME: THRD.ACME
WAIVER NO: RIW1234                  SCN: 6.7              PART NO: 12007766
ANALYSIS : Static+Fatigue          DATE: 20JUL84          SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF 14.50/14.50   ROOT RADII(in): EXT/INT .0058/.0058
HOLLOW DIA(EXT)(in):   5.600        SECTOR: 1.000  ENGAGEMENT LENGTH(in): 1.070
EQUIV O.D.(INT)(in):   7.000   LOAD FACTOR: 1.500   APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi):   0.000   TEMP(deg F):   160  MAX APPLIED LOAD(kip): 150.0
                      RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):   0.0
```

	TENSILE STRENGTH(ksi)	YIELD STRENGTH(ksi)	SURFACE FINISH
EXTERNAL	154.0	125.0	MACHINED
INTERNAL	154.0	125.0	MACHINED

```
*******        DEVIATING MAJOR DIA(in) INT THRD =  6.5200          *******
*******        DEVIATING PITCH DIA(in) INT THRD =  6.4800          *******
*******        DEVIATING MAJOR DIA(in) INT THRD =  6.4300          *******

SHEAR CAP (kip) Y.S./T.S.: EXT =   1356.86/  1671.65   INT=   1356.86/  1671.65
```

MATL	LOAD CAP(kip)		STATIC SF		SAFETY FACTORS FOR FATIGUE CYCLE RANGES						
COND	YS	TS	YS	TS	1*10E3	3*10E3	1*10E4	4*10E4	1*10E5	1*10E6	1*10E7
EMAX	281.3/	346.6	1.88/	2.31	1.6620	1.5118	1.3755	1.2462	1.1733	1.0229	1.0229
EMIN	245.1/	301.9	1.63/	2.01	1.4478	1.3169	1.1983	1.0856	1.0221	0.8911	0.8911
EACT	245.1/	301.9	1.63/	2.01	1.4478	1.3169	1.1983	1.0856	1.0221	0.8911	0.8911
IMAX	306.0/	376.9	2.04/	2.51	1.8075	1.6441	1.4960	1.3553	1.2760	1.1125	1.1125
IMIN	276.2/	340.2	1.84/	2.27	1.6315	1.4841	1.3503	1.2234	1.1518	1.0042	1.0042
IACT	248.3/	305.9	1.66/	2.04	1.4671	1.3345	1.2142	1.1001	1.0357	0.9029	0.9029
OVER- ALL	245.1/	301.9	1.63/	2.01	1.4478	1.3169	1.1983	1.0856	1.0221	0.8911	0.8911

PRESS RETURN FOR PROGRAM CONTROL MENU

```
                  *** THREAD DATA ***

 1. WAIVER NO: RIW1234        2. SCN#: 6.7            3. PART NO: 12007766
 4. METHOD: Static+Fatigue    5. DATE MACH: 20JUL84   6. SUBCODE: EXAMPLE
 7. BASIC DIA(in):  6.5000    8. THREADS/IN: 12.00    9. CLASS: 3C

10. THREAD FORM: ACME                      11. HOLLOW DIA(in):   5.600
    PF ANGLE(deg): 14.50                   12. EQUIV O.D.(in):   7.000
    CL ANGLE(deg): 14.50                   13. ENGAGEMENT LENGTH(in):  1.07
    EXT ROOT RADIUS(in): .0058             14. INTERRUPTED THRD FACTOR: 1.000
    INT ROOT RADIUS(in): .0058             15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 154.00     17. T.S. INT MEMBER( ksi) 154.00
18. Y.S. EXT MEMBER(ksi): 125.00     19. Y.S. INT MEMBER( ksi) 125.00
20. SURF EXT MEMBER: MACHINED        21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD         SPEC              DEV           VAR
22. MAJOR DIA(in)        6.5000-.0038      0.0000        0.00000
23. PITCH DIA(in)        6.4430-.0111      0.0000        0.00000
24. MINOR DIA(in)        6.4067-.0168      0.0000        0.00000
   INTERNAL THREAD         SPEC              DEV           VAR
25. MAJOR DIA(in)        6.5025+.0090      6.5200        0.00850
26. PITCH DIA(in)        6.4583+.0112      6.4800        0.01050
27. MINOR DIA(in)        6.4250+.0042      6.4300        0.00080

28. APPLIED PRELOAD(kip):      0.00       DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):      0.00        FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):    150.00 (max)      0.00 (min)
30. INTERNAL PRESSURE(ksi):      0.00
31. TEMPERATURE(deg F):  160               32. FATIGUE DATA REL: .5000

 NOTE:  THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.
BL TO SPEC: .0194            BL TO DEV: .0249

     PRESS RETURN FOR PROGRAM CONTROL MENU
```

*** THREADED JOINT STRESS ANALYSIS RESULTS ***

```
THREAD TYPE:  6.500-12 STUB ACME-3          FILE NAME: THRD.ACME
WAIVER NO: RIW1234                 SCN: 6.7            PART NO: 12007766
ANALYSIS : Static+Fatigue         DATE: 20JUL84        SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF 14.50/14.50    ROOT RADII(in): EXT/INT .0004/.0004
HOLLOW DIA(EXT)(in):   5.600      SECTOR: 1.000  ENGAGEMENT LENGTH(in): 1.070
EQUIV O.D.(INT)(in):   7.000 LOAD FACTOR: 1.500   APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi):   0.000  TEMP(deg F):   160  MAX APPLIED LOAD(kip):  40.0
                     RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):   0.0

            TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi)    SURFACE FINISH
EXTERNAL           154.0                   125.0              MACHINED
INTERNAL           154.0                   125.0              MACHINED

*******          DEVIATING MAJOR DIA(in) INT THRD =  6.5300           *******
*******          DEVIATING PITCH DIA(in) INT THRD =  6.5100           *******
*******          DEVIATING MAJOR DIA(in) INT THRD =  6.5000           *******

SHEAR CAP (kip) Y.S./T.S.: EXT =   1361.25/  1677.06   INT=   1361.25/  1677.06
```

MATL COND	LOAD CAP(kip) YS	LOAD CAP(kip) TS	STATIC SF YS	STATIC SF TS	SAFETY FACTORS FOR FATIGUE CYCLE RANGES 1*10E3	3*10E3	1*10E4	4*10E4	1*10E5	1*10E6	1*10E7
EMAX	87.1/	107.3	2.18/	2.68	2.6021	2.5540	2.5032	2.4472	2.4115	2.3263	2.3263
EMIN	67.4/	83.1	1.69/	2.08	2.0152	1.9780	1.9386	1.8953	1.8676	1.8017	1.8017
EACT	67.4/	83.1	1.69/	2.08	2.0152	1.9780	1.9386	1.8953	1.8676	1.8017	1.8017
IMAX	87.1/	107.3	2.18/	2.68	2.6037	2.5555	2.5047	2.4487	2.4130	2.3278	2.3278
IMIN	67.4/	83.0	1.68/	2.08	2.0135	1.9762	1.9369	1.8936	1.8660	1.8001	1.8001
IACT	64.7/	79.7	1.62/	1.99	1.9327	1.8969	1.8592	1.8176	1.7911	1.7278	1.7278
OVER-ALL	64.7/	79.7	1.62/	1.99	1.9327	1.8969	1.8592	1.8176	1.7911	1.7278	1.7278

PRESS RETURN FOR PROGRAM CONTROL MENU

*** THREAD DATA ***

```
 1. WAIVER NO: RIW1234          2. SCN#: 6.7              3. PART NO: 12007766
 4. METHOD: Static+Fatigue      5. DATE MACH: 20JUL84     6. SUBCODE: EXAMPLE
 7. BASIC DIA(in):  6.5000      8. THREADS/IN: 12.00      9. CLASS: 3

10. THREAD FORM: STUB ACME                        11. HOLLOW DIA(in):  5.600
    PF ANGLE(deg): 14.50                          12. EQUIV O.D.(in):  7.000
    CL ANGLE(deg): 14.50                          13. ENGAGEMENT LENGTH(in):  1.07
    EXT ROOT RADIUS(in): .0004                    14. INTERRUPTED THRD FACTOR: 1.000
    INT ROOT RADIUS(in): .0004                    15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 154.00      17. T.S. INT MEMBER( ksi) 154.00
18. Y.S. EXT MEMBER(ksi): 125.00      19. Y.S. INT MEMBER( ksi) 125.00
20. SURF EXT MEMBER: MACHINED         21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD           SPEC             DEV           VAR
22. MAJOR DIA(in)         6.5000-.0042      0.0000        0.00000
23. PITCH DIA(in)         6.4588-.0178      0.0000        0.00000
24. MINOR DIA(in)         6.4483-.0178      0.0000        0.00000
   INTERNAL THREAD           SPEC             DEV           VAR
25. MAJOR DIA(in)         6.5100+.0178      6.5300        0.00220
26. PITCH DIA(in)         6.4792+.0178      6.5100        0.01300
27. MINOR DIA(in)         6.4583+.0042      6.5000        0.03750

28. APPLIED PRELOAD(kip):      0.00      DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):     0.00        FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):     40.00 (max)     0.00 (min)
30. INTERNAL PRESSURE(ksi):     0.00
31. TEMPERATURE(deg F):  160              32. FATIGUE DATA REL: .5000

 NOTE:  THREAD BACKLASH CONDITIONS ARE AS FOLLOWS.
BL TO SPEC: .0290            BL TO DEV: .0357
ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):
```

```
                *** THREADED JOINT STRESS ANALYSIS RESULTS ***

THREAD TYPE:  7.063- 6 BUTT-2                    FILE NAME: THRD.BUT1
WAIVER NO: RIW1234                 SCN: 12345           PART NO: 12007723
ANALYSIS : Static+Fatigue         DATE: 25JUL84         SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF  7.00/45.00    ROOT RADII(in): EXT/INT .0059/.0059
HOLLOW DIA(EXT)(in):  0.000        SECTOR: 0.480  ENGAGEMENT LENGTH(in): 3.180
EQUIV O.D.(INT)(in):  8.300   LOAD FACTOR: 1.500   APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi):  0.000   TEMP(deg F):   200  MAX APPLIED LOAD(kip): 122.2
                   RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):   0.0

            TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi)     SURFACE FINISH
EXTERNAL            160.0                  130.0               MACHINED
INTERNAL            120.0                   95.0               MACHINED

*******          DEVIATING MAJOR DIA(in) EXT THRD =  7.0300             *******
*******          DEVIATING PITCH DIA(in) EXT THRD =  6.9000             *******

SHEAR CAP (kip) Y.S./T.S.: EXT =   6851.56/  8432.69   INT=   5006.91/  6324.52

MATL  LOAD CAP(kip)  STATIC SF     SAFETY FACTORS FOR FATIGUE CYCLE RANGES
COND    YS     TS     YS    TS   1*10E3 3*10E3 1*10E4 4*10E4 1*10E5 1*10E6 1*10E7

EMAX  712.0/ 876.3   5.83/ 7.17  3.5687 3.2472 2.9553 2.6782 2.5219 2.1993 2.1993
EMIN  664.7/ 818.1   5.44/ 6.69  3.3316 3.0315 2.7590 2.5003 2.3544 2.0532 2.0532
EACT  654.2/ 805.1   5.35/ 6.59  3.2790 2.9836 2.7154 2.4608 2.3172 2.0208 2.0208
IMAX  460.8/ 582.1   3.77/ 4.76  3.0711 2.7289 2.4318 2.1610 2.0128 1.7170 1.7170
IMIN  432.1/ 545.8   3.54/ 4.47  2.8796 2.5586 2.2801 2.0262 1.8873 1.6099 1.6099
IACT  432.1/ 545.8   3.54/ 4.47  2.8796 2.5586 2.2801 2.0262 1.8873 1.6099 1.6099
OVER-
 ALL  432.1/ 545.8   3.54/ 4.47  2.8796 2.5586 2.2801 2.0262 1.8873 1.6099 1.6099

     PRESS RETURN FOR PROGRAM CONTROL MENU
```

```
                 *** THREAD DATA ***

 1. WAIVER NO: RIW1234         2. SCN#: 12345           3. PART NO: 12007723
 4. METHOD: Static+Fatigue     5. DATE MACH: 25JUL84    6. SUBCODE: EXAMPLE
 7. BASIC DIA(in):  7.0625     8. THREADS/IN:  6.00     9. CLASS: 2

10. THREAD FORM: BUTT                          11. HOLLOW DIA(in):  0.000
    PF ANGLE(deg):  7.00                       12. EQUIV O.D.(in):  8.300
    CL ANGLE(deg): 45.00                       13. ENGAGEMENT LENGTH(in):  3.18
    EXT ROOT RADIUS(in): .0059                 14. INTERRUPTED THRD FACTOR: 0.480
    INT ROOT RADIUS(in): .0059                 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00     17. T.S. INT MEMBER( ksi) 120.00
18. Y.S. EXT MEMBER(ksi): 130.00     19. Y.S. INT MEMBER( ksi)  95.00
20. SURF EXT MEMBER: MACHINED        21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD            SPEC              DEV          VAR
22. MAJOR DIA(in)          7.0552-.0080       7.0300       -.01720
23. PITCH DIA(in)          6 9552-.0109       6.9000       -.04430
24. MINOR DIA(in)          6.8343-.0246       0.0000       0.00000
   INTERNAL THREAD            SPEC              DEV          VAR
25. MAJOR DIA(in)          7.0834+.0247       0.0000       0.00000
26. PITCH DIA(in)          6.9625+.0109       0.0000       0.00000
27. MINOR DIA(in)          6.8625+.0080       0.0000       0.00000

28. APPLIED PRELOAD(kip):       0.00      DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):      0.00        FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):   122.20 (max)       0.00 (min)
30. INTERNAL PRESSURE(ksi):      0.00
31. TEMPERATURE(deg F):  200               32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):
```

```
          *** THREADED JOINT STRESS ANALYSIS RESULTS ***

THREAD TYPE:  3.750- 6 BUTT-2                  FILE NAME: THRD.BUT2
WAIVER NO: RIW1234              SCN: 12345               PART NO: 12007723
ANALYSIS : Static+Fatigue      DATE: 25JUL84             SUBCODE: EXAMPLE

FLANK ANGLES(deg): PF/CF  7.00/45.00    ROOT RADII(in): EXT/INT .0059/.0059
HOLLOW DIA(EXT)(in):   0.000        SECTOR: 0.480  ENGAGEMENT LENGTH(in): 2.830
EQUIV O.D.(INT)(in):   6.000   LOAD FACTOR: 1.500   APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi):   0.000   TEMP(deg F):   200  MAX APPLIED LOAD(kip):  76.0
                   RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):   0.0

             TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi)     SURFACE FINISH
EXTERNAL             160.0                 130.0               MACHINED
INTERNAL             120.0                  95.0               MACHINED

*******          DEVIATING MAJOR DIA(in) INT THRD =  3.6000            *******

SHEAR CAP (kip) Y.S./T.S.: EXT =   3295.77/  4056.34   INT=   2408.45/  3042.25
```

MATL COND	LOAD CAP(kip) YS	LOAD CAP(kip) TS	STATIC SF YS	STATIC SF TS	SAFETY FACTORS FOR FATIGUE CYCLE RANGES 1*10E3	3*10E3	1*10E4	4*10E4	1*10E5	1*10E6	1*10E7
EMAX	312.1/	384.2	4.11/	5.05	2.5157	2.2390	2.0833	1.8879	1.7777	1.5504	1.5504
EMIN	293.1/	360.7	3.86/	4.75	2.3622	2.1494	1.9562	1.7727	1.6693	1.4558	1.4558
EACT	293.1/	360.7	3.86/	4.75	2.3622	2.1494	1.9562	1.7727	1.6693	1.4558	1.4558
IMAX	243.0/	306.9	3.20/	4.04	2.6037	2.3135	2.0617	1.8321	1.7065	1.4557	1.4557
IMIN	227.5/	287.4	2.99/	3.78	2.4382	2.1665	1.9307	1.7157	1.5980	1.3632	1.3632
IACT	227.5/	287.4	2.99/	3.78	2.4382	2.1665	1.9307	1.7157	1.5980	1.3632	1.3632
OVER-ALL	227.5/	287.4	2.99/	3.78	2.3622	2.1494	1.9307	1.7157	1.5980	1.3632	1.3632

PRESS RETURN FOR PROGRAM CONTROL MENU.

```
                    *** THREAD DATA ***

 1. WAIVER NO: RIW1234        2. SCN#: 12345          3. PART NO: 12007723
 4. METHOD: Static+Fatigue    5. DATE MACH: 25JUL84   6. SUBCODE: EXAMPLE
 7. BASIC DIA(in):   3.7500   8. THREADS/IN:   6.00   9. CLASS: 2

10. THREAD FORM: BUTT                         11. HOLLOW DIA(in):   0.000
    PF ANGLE(deg):   7.00                     12. EQUIV O.D.(in):   6.000
    CL ANGLE(deg): 45.00                      13. ENGAGEMENT LENGTH(in):   2.83
    EXT ROOT RADIUS(in): .0059                14. INTERRUPTED THRD FACTOR: 0.480
    INT ROOT RADIUS(in): .0059                15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00      17. T.S. INT MEMBER( ksi) 120.00
18. Y.S. EXT MEMBER(ksi): 130.00      19. Y.S. INT MEMBER( ksi)  95.00
20. SURF EXT MEMBER: MACHINED         21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD          SPEC             DEV           VAR
22. MAJOR DIA(in)        3.7432-.0050      0.0000        0.00000
23. PITCH DIA(in)        3.6432-.0102      0.0000        0.00000
24. MINOR DIA(in)        3.5223-.0239      0.0000        0.00000
   INTERNAL THREAD          SPEC             DEV           VAR
25. MAJOR DIA(in)        3.7709+.0239      0.0000        0.00000
26. PITCH DIA(in)        3.6500+.0102      0.0000        0.00000
27. MINOR DIA(in)        3.5500+.0050      3.6000        0.04500

28. APPLIED PRELOAD(kip):      0.00     DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):    0.00         FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):     76.00 (max)    0.00 (min)
30. INTERNAL PRESSURE(ksi):     0.00
31. TEMPERATURE(deg F):  200             32. FATIGUE DATA REL: .5000

ENTER ITEM TO BE CHANGED (0 FOR NO CHANGE):
```

```
*** THREADED JOINT STRESS ANALYSIS RESULTS ***

THREAD TYPE: 14.057-PF20-.3750                    FILE NAME: THRD.PF20
WAIVER NO: RIW1234                 SCN: 12345            PART NO: 12007723
ANALYSIS : Static+Fatigue         DATE: 25JUL84          SUBCODE: XXXX

FLANK ANGLES(deg): PF/CF 20.00/45.00    ROOT RADII(in): EXT/INT .0450/.0450
HOLLOW DIA(EXT)(in):  6.100        SECTOR: 0.480  ENGAGEMENT LENGTH(in): 3.530
EQUIV O.D.(INT)(in): 15.560   LOAD FACTOR: 1.500   APPLIED PRELOAD(kip):   0.0
INTERNAL PRESS(ksi): 25.100   TEMP(deg F):    160  MAX APPLIED LOAD(kip): 746.5
                     RELIABILITY(MEAN=0.5): 0.500  MIN APPLIED LOAD(kip):   0.0

             TENSILE STRENGTH(ksi)    YIELD STRENGTH(ksi)     SURFACE FINISH
EXTERNAL             160.0                  130.0              MACHINED
INTERNAL             120.0                   95.0              MACHINED

*******          DEVIATING PITCH DIA(in) INT THRD = 13.8540            *******
*******          DEVIATING MAJOR DIA(in) INT THRD = 13.7120            *******

SHEAR CAP (kip) Y.S./T.S.: EXT =  15445.86/ 19010.29   INT=  11287.36/ 14257.72

MATL  LOAD CAP(kip)  STATIC SF     SAFETY FACTORS FOR FATIGUE CYCLE RANGES
COND    YS     TS     YS    TS   1*10E3 3*10E3 1*10E4 4*10E4 1*10E5 1*10E6 1*10E7

EMAX 5376.3/6617.0  7.20/ 8.86  2.5310 2.2758 2.0493 1.8387 1.7217 1.4844 1.4844
EMIN 5291.1/6512.1  7.09/ 8.72  2.4909 2.2397 2.0169 1.8095 1.6944 1.4608 1.4608
EACT 5291.1/6512.1  7.09/ 8.72  2.4909 2.2397 2.0169 1.8095 1.6944 1.4608 1.4608
IMAX 2016.7/2547.5  2.70/ 3.41  2.2070 1.9094 1.6636 1.4489 1.3350 1.1148 1.1148
IMIN 1983.8/2505.9  2.66/ 3.36  2.1709 1.8782 1.6365 1.4252 1.3132 1.0966 1.0966
IACT 1976.5/2496.6  2.65/ 3.34  2.1629 1.8713 1.6304 1.4199 1.3083 1.0925 1.0925
OVER-
 ALL 1976.5/2496.6  2.65/ 3.34  2.1629 1.8713 1.6304 1.4199 1.3083 1.0925 1.0925

     PRESS RETURN FOR PROGRAM CONTROL MENU
```

*** THREAD DATA ***

```
 1. WAIVER NO: RIW1234          2. SCN#: 12345          3. PART NO: 12007723
 4. METHOD: Static+Fatigue      5. DATE MACH: __JUL84   6. SUBCODE: XXXX
 7. DATUM DIA(in): 13.8490      8. PITCH:   0.3750

10. THREAD FORM: PF20                          11. HOLLOW DIA(in):  6.100
    PF ANGLE(deg): 20.00                       12. EQUIV O.D.(in): 15.560
    CL ANGLE(deg): 45.00                       13. ENGAGEMENT LENGTH(in):  3.53
    EXT ROOT RADIUS(in): .0450                 14. INTERRUPTED THRD FACTOR: 0.480
    INT ROOT RADIUS(in): .0450                 15. LOAD FACTOR(1-4,1.5nom): 1.50

16. T.S. EXT MEMBER(ksi): 160.00       17. T.S. INT MEMBER( ksi) 120.00
18. Y.S. EXT MEMBER(ksi): 130.00       19. Y.S. INT MEMBER( ksi)  95.00
20. SURF EXT MEMBER: MACHINED          21. SURF INT MEMBER: MACHINED

   EXTERNAL THREAD           SPEC             DEV          VAR
22. MAJOR DIA(in)        14.0000-.0050       .0000       0.00000
23. PITCH DIA(in)        13.8490-.0000      0.0000       0.00000
24. MINOR DIA(in)        13.6410-.0100      0.0000       0.00000
   INTERNAL THREAD           SPEC             DEV          VAR
25. MAJOR DIA(in)        14.0570+.0100      0.0000       0.00000
26. PITCH DIA(in)        13.8490+.0000     13.8540       0.00500
27. MINOR DIA(in)        13.6980+.0050     13.7120       0.00900

28. APPLIED PRELOAD(kip):       0.00       DECIMAL OF MAX ALLOWABLE: 0.00
    APPROX TIGHTENING TORQUE(ft-lb):       0.00         FRICTION FACTOR: 0.20
29. AXIAL LOAD(kip):    746.50 (max)       0.00 (min)
30. INTERNAL PRESSURE(ksi):     25.10
31. TEMPERATURE(deg F):  160                32. FATIGUE DATA REL: .5000

    PRESS RETURN FOR PROGRAM CONTROL MENU
```